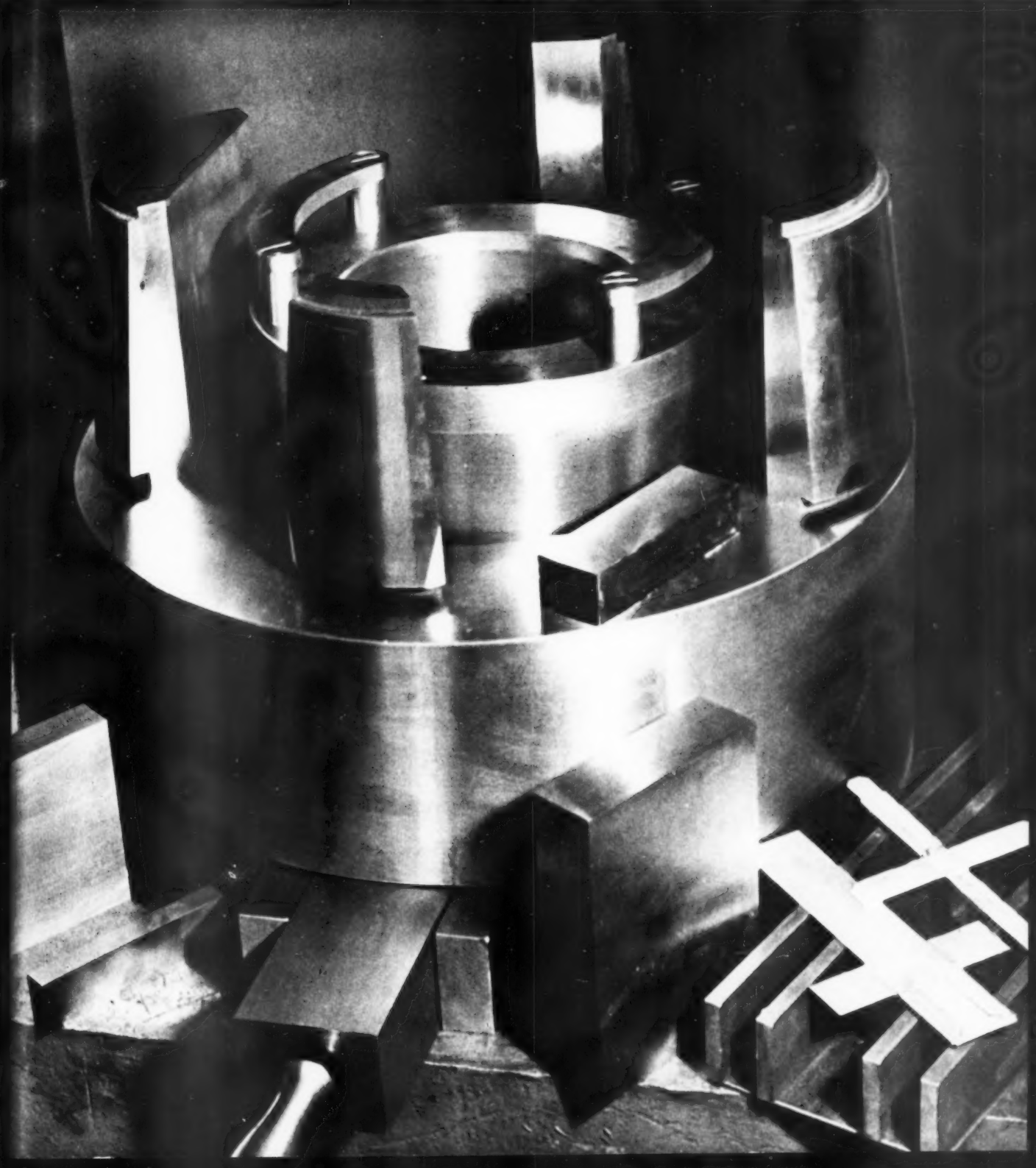
December 1943

TECHNOLOGY REVIEW

Title Reg in U. S. Pat. Office



Evening off Flamborough Head . . .

SEPTEMBER 23, 1779

The Bon Homme Richard, her decks a shambles. Raked from bow to stern. Hull blasted to a sieve, filling fast.

Shout from the Serapis' captain, "Have you struck?"

Then from his quarter deck, John Paul Jones lifted himself and his men to immortality with inspired words. Words that welled from an iron heart to set infectious courage leaping like wildfire through his crew. Words that made victory and founded naval tradition for an infant nation.

"No! I have not yet begun to fight!"

Today these words are still vital and inspiring at the work bench, at the bond booth—everywhere that men and women are working or fighting for victory.

PENFLEX responds with augmented effort so that more and more diesel exhausts, fuel oil feed, circulating water and starting air lines may speed the building and operation of the great armada of fighting and cargo ships that has grown from the tradition so brilliantly founded that September day.

Army and Navy requirements come first. However, if you are doing essential high priority war work and need flexible metallic tubing, write for Bulletins that will show you how PENFLEX can help you.

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.

PENFLEX METAL HOSE *Established 1902* 7250 POWERS LANE • PHILADELPHIA, PA.

He *used to be* an Expert Die Maker

PROTECT YOUR WORKERS' SKILL WITH AO SAFETY GOGGLES

Not so long ago, this man was a die maker by trade. Now he is a pencil peddler by accident. Let his case remind you that unless there is a properly planned eye protection program in your plant, industrial eye accidents can rob *you, too,* of highly skilled, *irreplaceable* workers.

Let this blind man remind you, also, of the *high costs* of eye accidents . . . in medical and hospital expenses, lost time, lost manpower, lost production, idle machines, spoiled materials. Even the most minor case of "Lost-Time Eyes" costs far more than the AO Goggles that would have prevented it.

American Optical Company offers you a complete line of scientifically designed, comfortable goggles for every type of eye hazard. Trained AO Safety Representatives give freely of their time and experience to help your Safety Director safeguard eyes and dollars. Get in touch with your nearest AO Branch Office today.

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

Manufacturers for 110 Years of Products to Aid and Protect Vision. Branches in All Principal Industrial Centers

THE TECHNOLOGY REVIEW, December, 1943. Vol. XLVI, No. 2. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

THIS NEW CHEMICAL STONEWARE REFUSES TO CRACK!

PACKED IN DRY ICE
BLASTED WITH LIVE STEAM
49% LESS WATER ABSORPTION
400% HIGHER THERMAL CONDUCTIVITY
27% GREATER MECHANICAL STRENGTH

THIS new "Ceratherm 500" will change your whole thinking about chemical stoneware equipment. Here, for the first time in the history of ceramics, is a chemical stoneware body, rugged, like cast iron, of low-porosity and high thermal conductivity, that will withstand abrupt heating and cooling!

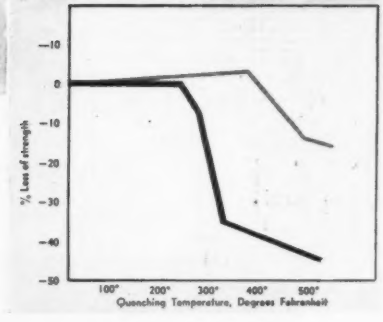
The most persistent claims raised against ordinary chemical stoneware have been its poor resistance to thermal strains and heat shocks, and its fragility. Admittedly tops from the standpoint of corrosion-resistance; admittedly the least expensive material from which equipment of odd size and unusual shape could be fabricated, chemical stoneware would have been specified for hundreds of additional applications if it had been able to withstand rough usage and sharp temperature changes.

"Ceratherm 500", U. S. Stoneware's new heat-shock resistant body does just that. Temperatures can be raised quickly over a wide range through direct application of steam or hot gases, even, in some cases by direct flame. Slow, cumbersome heating with hot oil or sand baths can be forgotten.

27% STRONGER

"Ceratherm 500's" marked resistance to thermal stresses has been obtained without sacrifice of mechanical strength, corrosion-resistance, or absorption characteristics. In fact, "Ceratherm 500" is initially 27% stronger mechanically (it actually increases in strength with thermal changes — see chart) than standard bodies now available. Its corrosion-resistance has been unaffected. Its thermal conductivity is almost 400% greater than ordinary stoneware. Its porosity, as measured by water absorption tests, is less than half the figure generally accepted as being within the limits of good chemical stoneware.

The cost? But a fraction more than standard bodies. In fact, on most items the cost differential is negligible.



This new "Ceratherm 500" actually shows an increase in mechanical strength (note chart at right) when heated to 400° F. and quenched, more than 100° beyond the point where ordinary chemical stoneware bodies begin to lose strength!

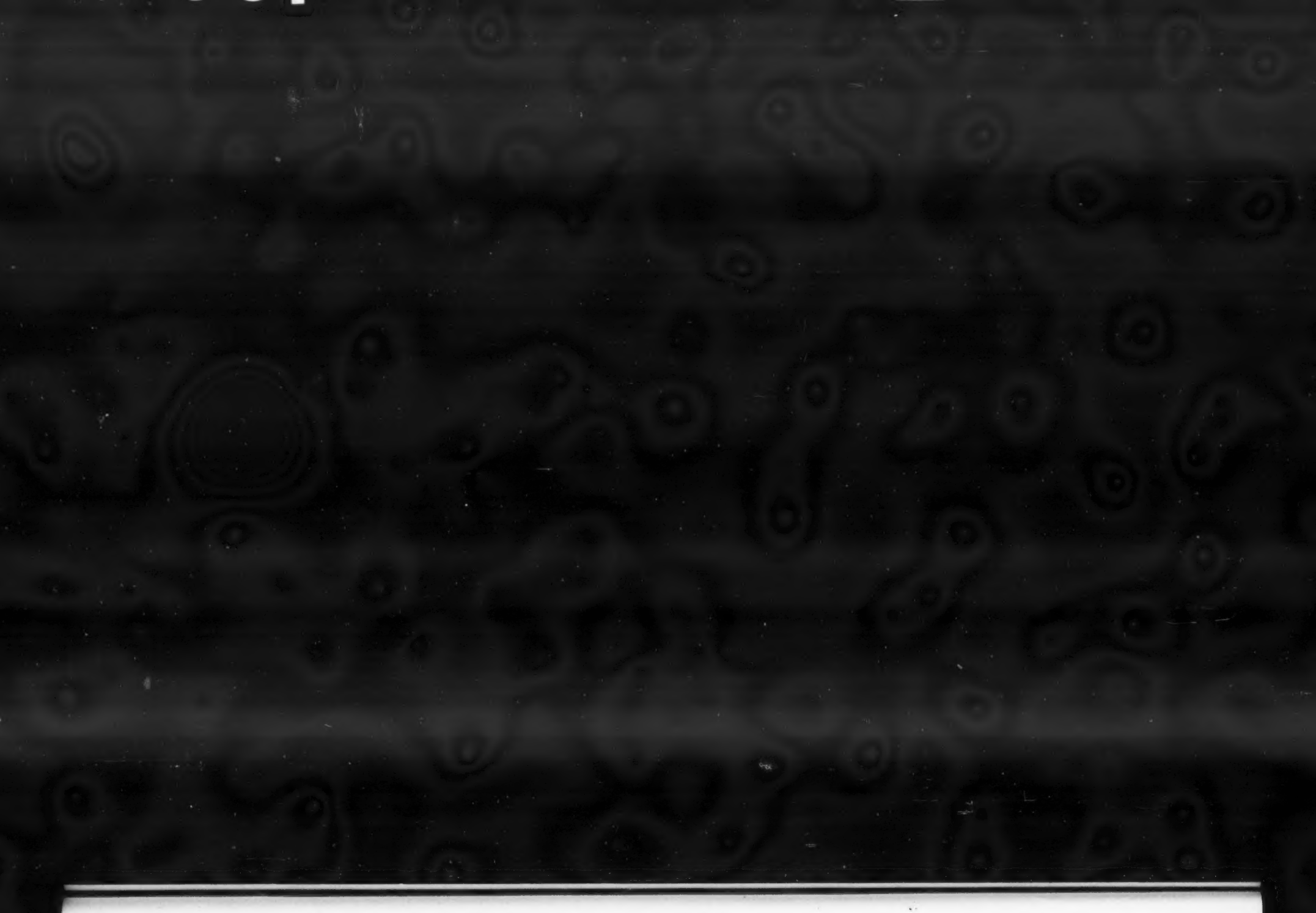
In the photograph above, a chemical stoneware pipe 10″ ID x 5′ x ¾″ wall thickness, made from "Ceratherm 500", was packed in dry ice of a temperature of —109° F. After an hour the pipe, still packed in dry ice, was subjected to repeated and prolonged blasts of super-heated steam of 125 lbs. pressure (equivalent to a temperature in excess of 325° F.). An ordinary chemical stoneware body would have been destroyed at the first turn of the steam valve. "Ceratherm 500" was unaffected.

"Ceratherm 500" is available now. Specify it for full-sized process equipment, such as boiling kettles, evaporating dishes, cooling coils, filters, tanks, mixing equipment, valves, pumps, or for any equipment where ruggedness, high thermal conductivity and heat-shock resistance are required.

U. S. STONEWARE

Since 1865 • Akron, Ohio

IN CANADA: CHAMBERLAIN ENGINEERING, LTD., MONTREAL



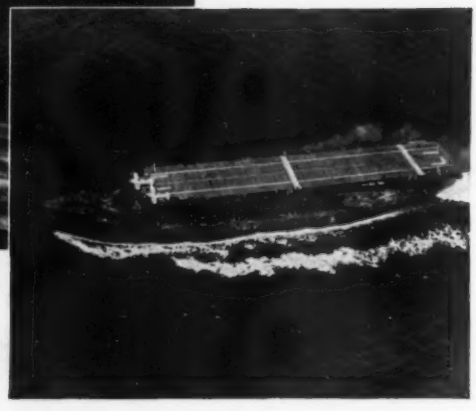
ARMY
E
NAVY
1943
THE WAR DEPARTMENT OF
THE UNITED STATES OF AMERICA
RECOGNIZES IN THIS AWARD FOR DISTINGUISHED SERVICE
THE LOYALTY ENERGY AND EFFICIENCY IN THE PERFORMANCE
OF THE WAR WORK BY WHICH
National Co.
AIDED MATERIALLY IN OBTAINING VICTORY FOR THE ARMS
OF THE UNITED STATES OF AMERICA IN THE WAR WITH
THE IMPERIAL GERMAN GOVERNMENT AND THE IMPERIAL
AND ROYAL AUSTRO-HUNGARIAN GOVERNMENT
1918

The men and women of National Company take great pride in the reception of the Army-Navy "E" Award for excellence in production. To us it brings a special satisfaction, for twenty-five years ago we received a similar award for service to the Nation in World War I. Old timers have set the pace in winning both awards, but new hands have joined with old skills in putting our difficult job across. It is our pride and our pledge that we of National Company shall keep our record of service bright.

NATIONAL COMPANY, INC.

MALDEN, MASS., U. S. A.

OFFICIAL U. S. NAVY PHOTOGRAPHS



Seeing Pictures Like These Makes the Headaches Worthwhile

As with most other plants, Busch-Sulzer found it no easy matter to throw its peacetime procedure by the board overnight and get into a full stride of war production. The Navy wanted ammunition hoists above all and quickly. Men, machines and tools had to start from scratch. New men had to be trained. Obstacle after obstacle had to be overcome.

Sooner than we hoped for, the ammunition hoists began leaving our plant. The Navy wanted Diesels and got them, too. The Department awarded Busch-Sulzer its E—and then a star, a second star and now a third.

Now, these official U. S. Navy photographs show what the headaches have helped to accomplish. The 'flat top' is the U. S. S. Long Island, an auxiliary aircraft escort vessel of the type that has been much in the news lately. It is powered by Busch-Sulzer Diesels. The other picture shows the 5″/38s of a battleship being fired. These dual-purpose guns are served by ammunition hoists of the type made by Busch-Sulzer. The hoists are made with watch-like precision. Just what they do for the gun is one of those stories that will astonish you after the war.

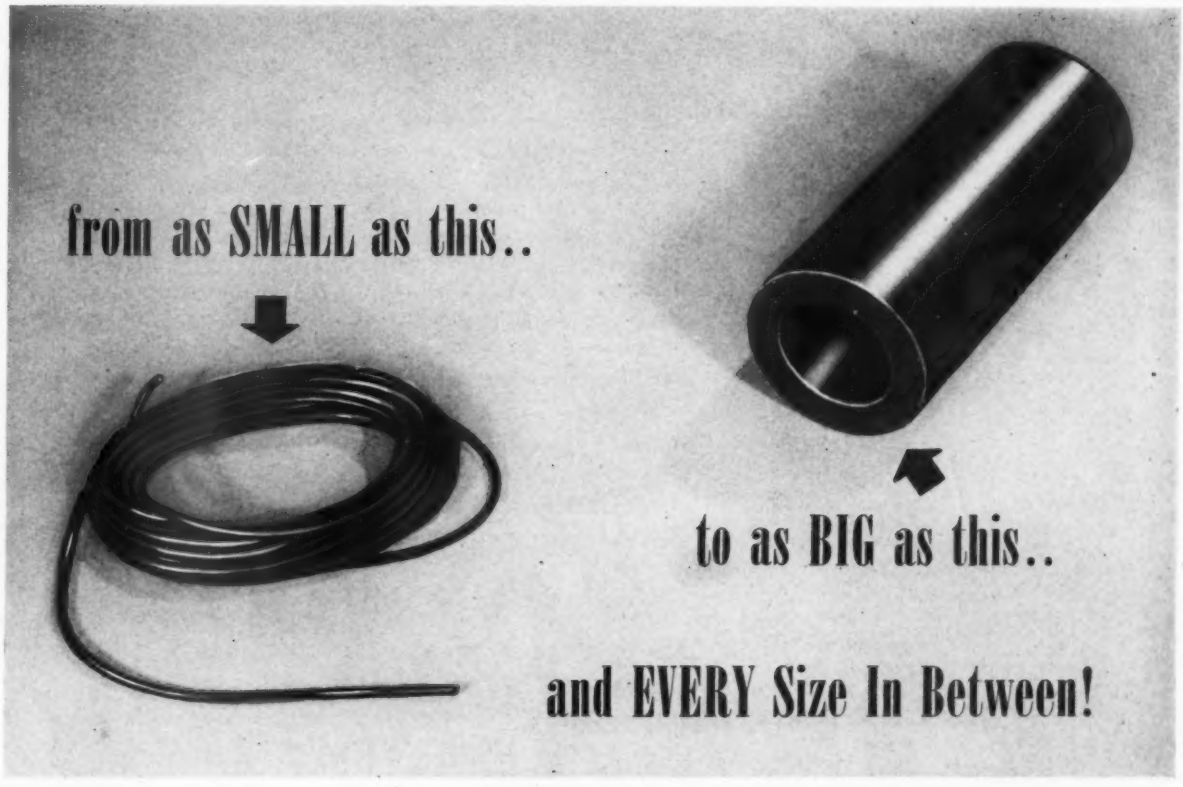
Right now it's good to know that skilled American workmen have done and are doing their share to hasten the hour of victory.

BUSCH-SULZER BROS. DIESEL ENGINE COMPANY

SAINT LOUIS

BUSCH-SULZER ST. LOUIS

AMERICA'S OLDEST BUILDER OF DIESEL ENGINES



Sandee

FLEXIBLE PLASTIC TUBING

Custom-made to every practical size and thickness, the uses for SANDEE Flexible Plastic Tubing are practically unlimited. Investigate this modern product for insulating electrical wire and cable. It's made in all the N.E.M.A. colors. Consider it also for acid drains, oil lines, air hosing, and other such uses. Sandee Plastic Tubing is highly resistant to acids, oils, greases, is non-oxidizing and possesses ample tensile strength. No matter what size, thickness, length, color, or degree of flexibility . . there's a SANDEE *Flexible* Plastic Tubing to meet practically every need. Let our skilled plastic engineers help you on production problems. Send for samples and complete information, today. ★ Sandee also manufactures a large line of stock and custom-made extruded *rigid* plastic sections. Complete information on request.

ELMER SZANTAY, M.E. '35, GENERAL MANAGER

Sandee Manufacturing Company

3945 NORTH WESTERN AVENUE · CHICAGO, ILLINOIS

EXTRUDED PLASTICS AND SPECIAL TOOLS

"PUT IT ON THE BLANCHARD"

CHECK THESE ADVANTAGES OF BLANCHARD GRINDING

- Production
- ★ Adaptability
- Fixture Saving
- Operation Saving
- Material Saving
- Fine Finish
- ★ Flatness
- ★ Close Limits

★ . . . . . *Especially valuable on jobs like the one illustrated.*

HERE are two surface grinding problems that came to the Blanchard Engineering Department in one week:

(1) Grind a hardened steel ring 86½" in diameter to a tolerance of ±.0002" for thickness.

(2) Grind the edges of a steel strip, .005" thick, .125" wide, and 20" long, straight and to a tolerance of ±.0005".

Thirty years' experience in grinding flat surfaces enabled Blanchard Engineers to solve the grinding of both of these jobs, using Blanchard vertical Surface Grinders and Blanchard Grinding Wheels.

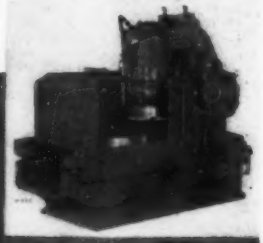
If you have work which lies within the range here indicated, you should investigate the possibilities of a Blanchard.

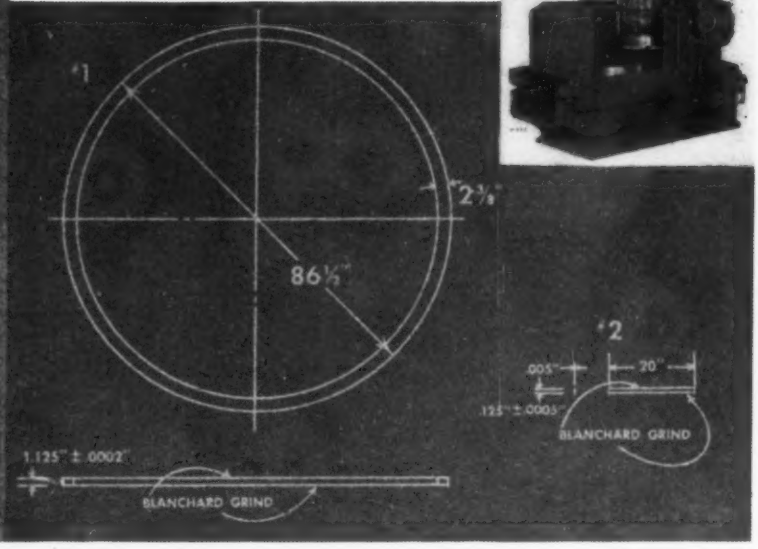
Whether the job is large or small, usual or unusual, Blanchard can show you how to grind it better and faster.

The BLANCHARD MACHINE COMPANY

64 STATE STREET, CAMBRIDGE, MASS.

Grinding Hardened Steel Rings and Edges of Steel Strip on Blanchard Surface Grinders.





BLANCHARD

Send for your free copy of "Work Done on the Blanchard." This book shows over 100 actual jobs where the Blanchard Principle is earning profits for Blanchard owners.

The Spark that Lights the Flame of Victory

A pinpoint of fighting metal placed in the arc of the spectrograph writes its own signature on a photographic plate. Inside the instrument, the light from that flame is broken up by a prism as a prism breaks up sunlight. Each element identifies itself by a series of characteristic lines, always the same for the same basic element. It reveals to the spectrographer each constituent, what impurities are present and in what quantities.

Thus spectrography helps in controlling inspection. It keeps tough fighting steels tough, helps in development of new fighting metals. Spectrography is used too in other fields . . . chemicals, foodstuffs, vitamins. It speeds research, control, and analysis. Today, spectrography is helping to build the tools of Victory as in peacetime it helps to make better cars and better breakfast foods.

Because Bausch & Lomb had long experience with such precision optical equipment needed in education, research, and industry, it was ready for quantity production of precision optical instruments of war such as gunfire control instruments, binoculars, and aerial photographic lenses. When the last gun is fired, Bausch & Lomb will devote its enlarged experience to peacetime optical production. Through war and peace, Bausch & Lomb has continued . . . and will continue . . . to do the job it knows how to do best. *Here again optical science is seeing it through.*

For Bausch & Lomb Instruments essential to Victory—priorities govern delivery schedules.

BAUSCH & LOMB

OPTICAL CO. • ROCHESTER, N. Y.

ESTABLISHED 1853

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR MILITARY USE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION

High Rifle Output Depends on Pumps

to maintain uninterrupted hydraulic operation of rifling machines. Brown & Sharpe Motor Driven Rotary Geared Pumps were chosen for this vital war need because of unfailing performance.

Motor Driven Rotary Geared Pumps as well as other Geared, Vane and Centrifugal Pumps, are shown in our pump catalog. Copy forwarded upon request. Brown & Sharpe Mfg. Co., Providence, R. I., U. S. A.

BROWN & SHARPE PUMPS

BATH
IRON WORKS
CORPORATION

Shipbuilders and Engineers

•

BATH, MAINE

THE TABULAR VIEW

Twoscore. — It lacked eight days of Christmas in 1903 when Orville Wright started a telegram on the way to his father, reporting a world-shaking event in characteristically unpretentious style: "Success four flights Thursday morning all against twenty-one-mile wind started from level with engine power alone average speed through air thirty-one miles longest 59 seconds inform press home Christmas." This month, 40 years after that windy Thursday on the dunes of Kitty Hawk, The Review presents (page 83) an evaluation of what Orville and Wilbur Wright had to do to bring to pass man's most ancient desire. FRED C. KELLY, one of the members of the press who then paid little heed to the announcement in that telegram, has in the years since worked closely with Dr. Wright on the history of the achievement of 1903. Mr. Kelly's biography, *The Wright Brothers*, authorized by Orville Wright, appeared last spring. His essay in this Review is marked by the trenchant style which makes him a notable companion in contemporary letters. A pictorial footnote of especial interest to Technology people appears on page 93 — a photograph recalling Dr. Wright's attendance at the dedication of the Institute's Cambridge home in 1916, when the *Wright Flyer* was exhibited.

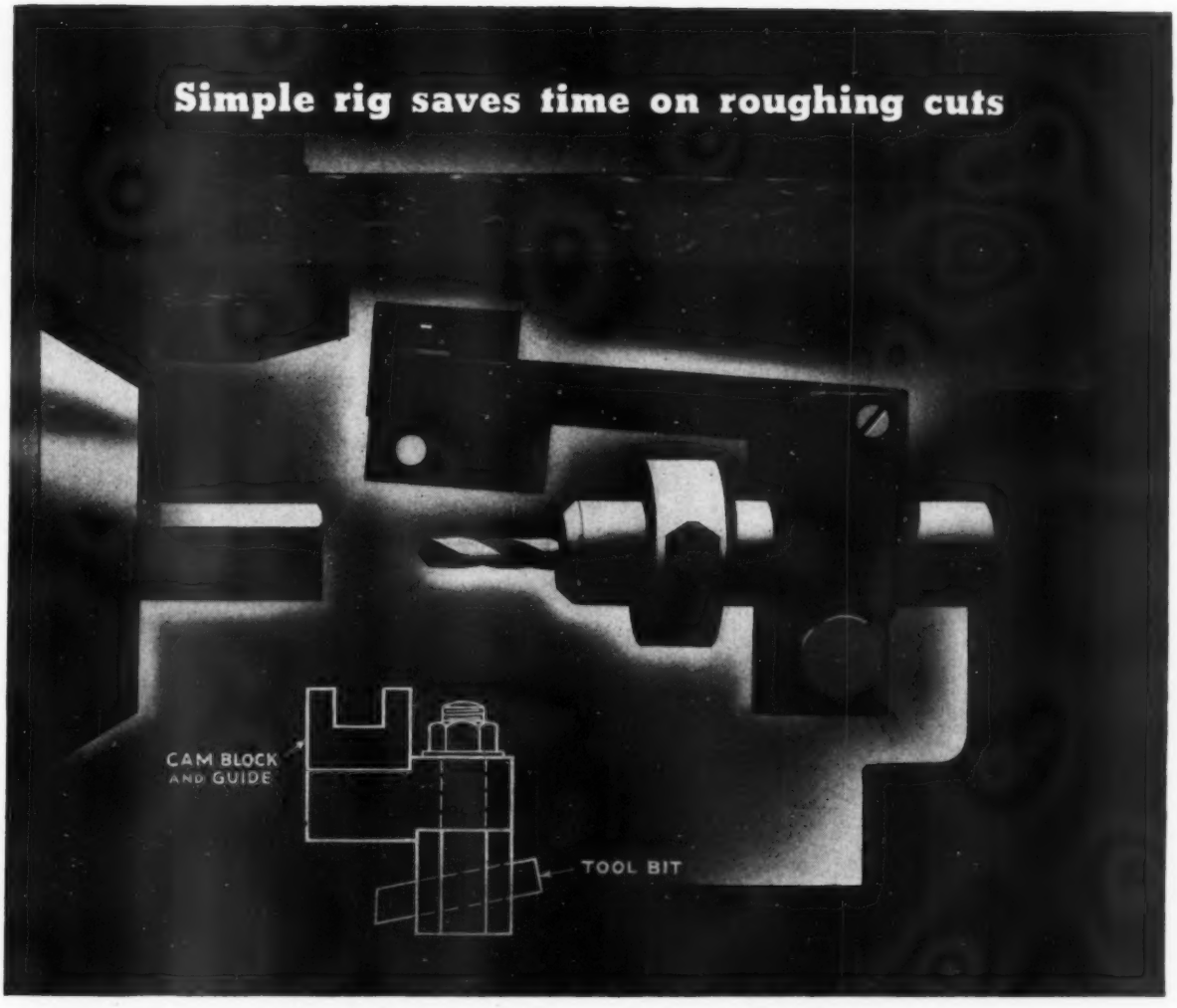
Team. — How science, industry, and American military men have worked together for the winning of this war is implicit in all parts of the record of recent years. For The Review, BRIGADIER GENERAL ALDEN H. WAITT, assistant chief for field operations, Chemical Warfare Service, brings an area of that record into sharp focus in an article (page 85) describing the development of a new smoke generator which has proved of great value in the screening of important targets against air attack. An Alumnus of the Institute, Class of 1914, General Waitt is one of the few original World War chemical warfare officers remaining in our Regular Army. He is a frequent contributor to magazines and is the author of *Gas Warfare*, accepted as the standard book in the field.

Futures. — It is appropriate that in the anniversary month of the Wrights' success, consideration should be given to our future use of the vast fleets of transport aircraft now in operation for military purposes. L. WELCH POGUE, chairman of the Civil Aeronautics Board, argues cogently (page 88) the necessity for sound planning to meet this problem of the postwar years. An able and farseeing administrator, Mr. Pogue is a graduate of the University of Nebraska; he served as general counsel for the Civil Aeronautics Board before assuming his present post.

Plant Plans. — Trends in the construction of industrial buildings, now possibly of academic interest except in so far as large-scale war plants are concerned, will be of major concern to American communities in years to come. They are discussed (page 90) by HERBERT S. SWAN, city planner and industrial consultant, who frequently comments on social phenomena for The Review. Projects for urban rehabilitation which are counted on as assistance in restoring peacetime equilibrium of employment cannot but be influenced by the developments which his article discusses.

Hot. — Application of electronic principles to the bonding of plywood is an industrial development of decided importance. THOMAS D. PERRY, who explains (page 80) the technique and its advantages, was graduated from the Institute in 1900, and is sales and development engineer for the Resinous Products and Chemical Company. For some 30 years he has been associated with the development of plywood by American industry and is the author of an authoritative volume on the subject.

Simple rig saves time on roughing cuts



Information supplied by an Industrial Publication

Roughing tools conventionally mounted on turret lathes or hand screw machines have a tough time cutting hex bar stock. Intermittent cutting, accompanied by successive severe shocks make frequent resharpening necessary. This means equally frequent machine shutdowns.

The problem of eliminating the lost time on such jobs has been solved in a New England plant by an ingenious rig applied to some old turret lathes.

The rig consists essentially of two bars. One, carrying the roughing tool, is pivoted to the turret. The other, having a very simple adjustable cam on its lower side, is fastened between the top of the turret and a sliding support on the headstock.

As the turret advances the roughing tool, the cam feeds it downward, then guides it horizontally and supports it transversely while the roughing cut is made. A drill or other inside tool may be fed in to work simultaneously.

When the roughing cut is finished, the tool is backed off, and the finishing tool fed in on the cross slide. When the roughing tool needs resharpening, it is simply a matter of a few minutes to take it out of the holder and put a sharp tool in. Shutting down is unnecessary. There is less need for expert grinding and resetting.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

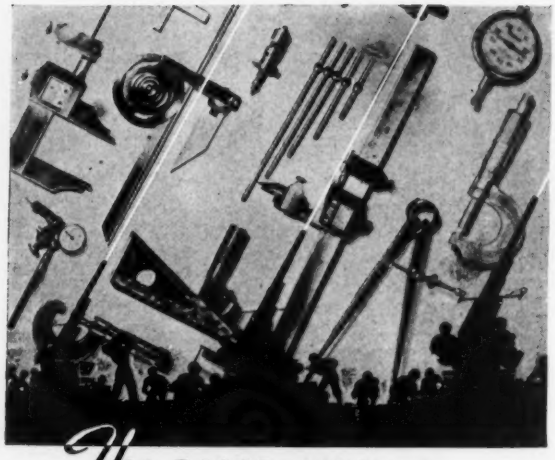
ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

500 Fifth Avenue • New York City

MOLY



The SAME AIM ...

Starrett Tools and the tools of war they're helping to make have many characteristics in common. Both are built for accurate, dependable performance under strenuous service conditions. Both are designed to supplement and sustain the skill and efficiency of their users — to help maintain the morale that hastens victory.

You may continue to put your trust in Starrett Tools.

Now, with Service Star

THE L. S. STARRETT CO., Athol, Massachusetts, U. S. A.
WORLD'S GREATEST TOOLMAKERS

STARRETT

PRECISION TOOLS • DIAL INDICATORS • GROUND FLAT STOCK
HACKSAWS • METAL CUTTING BANDSAWS • STEEL TAPES

MAIL RETURNS

Rehabilitation

FROM AMBROSE TERWILLIGER:

The thoughtful paper of Mr. Moholy-Nagy in your magazine for November opens up discussion of a subject which should evoke the careful consideration of all patriotic Americans at once. We have begun already to face the issue, and it will be more forcefully placed before us month by month as this war proceeds: How shall we best discharge the physical debt which every one of us will owe to men who have sacrificed part of their bodily well-being in order to do their part in putting down the brutish aggression which threatened us with the overthrow of principles and institutions that we have historically regarded as basic in human decency?

As a very slight contribution in further extension of your author's excellent proposals, I want to suggest that the very name which we have been in the custom of applying to the means by which we have insufficiently discharged this debt in the past is, to say the least, a very poor one.

You "rehabilitate" cities, maybe, or buildings. It does not seem to me that you rehabilitate men. I find in the term a weak overtone, and I think that it ought to be eliminated. Don't ask me, though, what should take its place. Before addressing you, I combed dictionary and thesaurus, and have to confess that the language here, as in so many other recent technological and scientific situations, falls short of providing an acceptable alternative.

Is this another of the more and more frequently encountered situations which demand that we fly in the face of professors and coin a word to meet a need?

Cambridge, Mass.

— STEEL —

HOT AND COLD ROLLED
DEFORMED BARS FOR CONCRETE

Stahleker Steel Corp.

Second and Binney Sts., Kendall Sq., Cambridge, Mass.

Telephone Trowbridge 1440
WALLACE BLANCHARD, '16, *Treasurer*

★ ★ ★ ★ ★

"Peace On Earth"

We are fighting an enemy that has made a mockery of "Peace On Earth." An enemy that lacks, however, the one decisive force for Victory—the inner power that surges within a man when he is defending, with the skill of his workmanship, or the power of his sword, his God-given gift of Freedom!

DIEFENDORF GEAR CORP.
D. W. Diefendorf '30, *President*
SYRACUSE, NEW YORK

diefendorf
★★★★★ GEARS

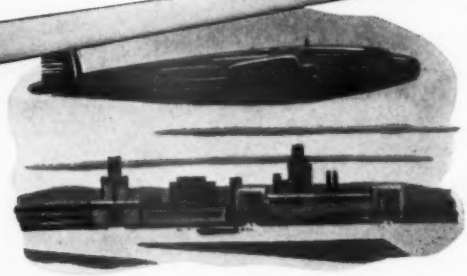
Speed with Economy

Air Reduction Sales Co.
(Alteration and Rehabilitation)

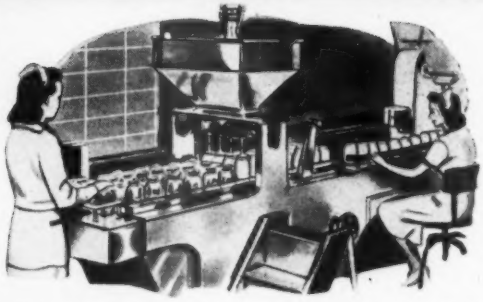
After the war, in converting plants to peacetime products, there will undoubtedly be quite a demand for alteration and reconstruction. . . . You will find that we can offer you valuable suggestions on such projects — *based on long experience.*

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, Vice President

Filling Prescriptions with Steel!



1. BETTER STEELS! This country needs aircraft that fly high and far . . . and hit hard. It needs ships in great numbers. It needs tanks that can take it when the going gets tough. It needs equipment to outperform any on earth. All these things require many special steels. Such steels with needed properties are created through the use of *alloys*. Basic peacetime research by ELECTRO METALLURGICAL COMPANY, a Unit of UCC, has developed many important steels and the alloys to make them, such as chromium, silicon, manganese, vanadium, tungsten, calcium, and columbium . . . all vital today.



2. STAINLESS STEELS! The development of steels of high chromium content gave designers and engineers a whole family of new materials with which to work. Such steels resist rust and corrosion, and are easily kept clean. They are essential in the food industry. Possessing great strength in addition to their corrosion resistance, they save weight in trains and planes. They have brought improvements in the oil, chemical, textile, and other fields...with resultant savings to you. Low-carbon ferrochromium, an Electromet development, is essential in the large-scale production of stainless steels.

3. NEW NATIONAL RESOURCES! Tungsten and vanadium are essential to steelmakers. Long before war clouds loomed, many felt that more of this country's domestic sources of these metals should be developed. Engineering research by UNITED STATES VANADIUM CORPORATION, another UCC Unit, found efficient ways of refining low-grade ores. This enabled U. S. VANADIUM to revitalize old mines with new mills and methods, and make America less dependent on foreign sources for her increased needs of tungsten and vanadium.

4. BUILDING TOWARDS THE FUTURE! Alloy steels offer still greater promise for the future. Bridges and other structures will be made still lighter, stronger, and longer-lasting by wider use of some of the steels with which engineers are already experienced. Trains, trucks, and aircraft will be made lighter, stronger, faster, and safer. Better cars and tractors, homes and home equipment will be made through their use.

Units of UCC do not make steel. They do make ferro-alloys used to purify and give special properties to steel. They also make non-ferrous alloys which, because of their exceptional resistance to wear, heat, and corrosion, are used as cutting tools, hard-facing welding rods, and for other purposes. UCC research and developments mean ever-new and improved alloys for industry . . . and ever-better products for you.

BUY UNITED STATES WAR BONDS AND STAMPS

UNION CARBIDE AND CARBON CORPORATION

30 East 42nd Street UCC New York 17, N. Y.

Principal Products and Units in the United States

ALLOYS AND METALS
Electro Metallurgical Company
Haynes Stellite Company
United States Vanadium Corporation

CHEMICALS
Carbide and Carbon Chemicals Corporation

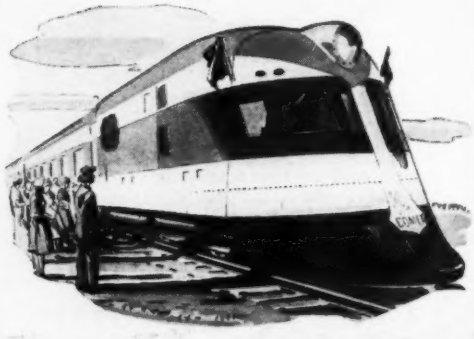
ELECTRODES, CARBONS AND BATTERIES
National Carbon Company, Inc.

INDUSTRIAL GASES AND CARBIDE
The Linde Air Products Company
The Oxweld Railroad Service Company
The Prest-O-Lite Company, Inc.

PLASTICS
Bakelite Corporation
Plastics Division of Carbide and Carbon Chemicals Corporation

Trail Blazing in the Skies

1935



FIRST STREAMLINER BUILT ON AERONAUTICAL PRINCIPLES was the famous "Comet," designed and fabricated by Goodyear's Aircraft division in 1935 for the New York, New Haven & Hartford Railroad. In the Comet, lightness-with-strength was achieved by designing roof, sides and floor of the cars as main load-carrying elements of the structure — the same stressed-skin or monocoque construction widely used in aircraft. This undertaking was part of Goodyear's early work in exploring the possibilities of light aircraft metals that contributed to the development of the superior alloys in use today.

1943

METALCRAFTING EXPERIENCE THAT STREAMLINES MANY PRODUCTION PROBLEMS. As a result of its long experience in aeronautical design and light-metal fabrication, Goodyear is today one of the largest producers of subassemblies for all types of aircraft. These include complete empennages and wing panel assemblies, and all their component parts, cabin structures, floats, and float mechanisms — for both "hot" fighters and heavy bombers. And in addition Goodyear is one of the producers of the Corsair — a fact that bespeaks Goodyear's ability to handle complete and intricate production problems on a large scale.

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Benjamin W. Irvin, Jr., '38

A horselaugh from a museum garden in Rome

VOLUME 46 NUMBER 2

THE TECHNOLOGY REVIEW

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CONTENTS for DECEMBER, 1943

THE COVER — A Pressing Die for Powder Metallurgy

From a photograph by Fritz Goro from Black Star

ON KILL DEVIL HILL — Frontispiece — 78

ELECTRICITY FOR PLYWOOD — By Thomas D. Perry — 80

THE REVOLUTION AT KITTY HAWK — By Fred C. Kelly — 83

What the Achievement of the Airplane Owed to the Past

SMOKE, BUT NO FIRE — By Alden H. Waitt — 85

A Notable Method for Smoke-screening Targets

TODAY'S AIRPLANES TOMORROW — By L. Welch Pogue — 88

Sound Plans for Peacetime Handling of Wartime Transport Fleets Are Essential

INDUSTRIAL BUILDING TRENDS — By Herbert S. Swan — 90

Factories Must Be Calculated for the Work to Be Done in Them

☆ ☆ ☆

THE TABULAR VIEW — 72

Contributors and Contributions

MAIL RETURNS — 74

Letters from Review Readers

THE TREND OF AFFAIRS — 79

News of Science and Engineering

THE INSTITUTE GAZETTE — 92

Relating to the Massachusetts Institute of Technology

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ON KILL DEVIL HILL

The Wright Memorial is silhouetted broodingly against the evening sky near where sustained flight in a heavier-than-air machine was achieved on December 17, 1903.

THE
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Vol. 46, No. 2

December, 1943

The Trend of Affairs

Deus ex Machina

IN building up his arguments for the theory of evolution, Darwin felt it necessary to explain how species may spread over the earth, often across natural barriers which at first thought would appear insurmountable by the particular plant or animal. Slow climatic changes might permit the gradual spread of a species, seeds might lodge on the beaks or talons or in the intestines of birds and be transported to new continents and islands, burs might stick in the fur of animals, a fruit with a specially impervious covering might float for great distances in ocean currents and finally, after perhaps millions of tries, one of them might find a suitable lodging place, and so on. Nevertheless, only a comparative handful of species have the mechanism or the endurance to permit much traveling. It is an incident worthy of note when even a whale, positively marked in one ocean, is picked up in another. The great barriers of temperature, oceans, deserts, mountain ranges, and many other comparable conditions have succeeded in restricting most important geographical regions to their own typical flora and fauna. In spite of much mingling and merging, few areas of any extent are found to be without plants, animals, or insects peculiar to them.

Thus, for many aeons the mosquito *Anopheles gambiae* gave the dubious distinction of its presence to tropical Africa alone. Less than 2,000 miles away to the west lay the equally salubrious (for the mosquito) jungles of the Amazon basin, but no natural means were available to give the mosquito passage. Then, in 1930, the French republic being desirous of establishing an air route between its African possessions and Brazil, various of its planes and destroyers began traveling back and forth between Dakar and Natal. By one of these means this particularly dangerous mosquito reached Brazil, where its further progress was marked by outbreaks of a severe form of malaria against which science was successfully marshaled by the Rockefeller Foundation.

The brotherly sharing of diseases and pests has long been a feature of man's movements over the planet. Undoubtedly smallpox, tuberculosis, pneumonia, scarlet fever, and measles (all unexpectedly fatal to peoples not immunized by long association) had a far greater part than warfare in clearing America for European settlers, just as such diseases have ravaged the native populations of tropic regions and, as far as that goes, just as tropical diseases have been and are being brought into temperate zones. Here, luckily, the climate is a great aid in disposing of them. Ships have brought to this country the Hessian fly (one of the earliest problems to trouble our oldest scientific organization, the American Philosophical Society), the Japanese beetle, and the Dutch elm disease, just as they have carried American pests abroad.

These are typical of unpremeditated exchanges, but in so far as man has played the role of *deus ex machina* to various bacteria, plants, and insects, he has done it not merely by chance but by design. Darwin could have logically insisted that a 50,000-horsepower destroyer carrying a mosquito is in the same class with a tern carrying a grass seed. What is to be said, however, for the deliberate transplanting of plants and animals to new regions in the hope of some benefit? Here man is truly the god of the machine to nature, stepping in when it pleases him to solve difficulties in transportation far beyond the possibilities of natural mechanisms.

Consider the banana. Presumed to have originated in the humid, tropical regions of southeastern Asia, it was carried from there to the islands of the Pacific by successive migrations. In the other direction, it was carried to Africa from India by Arab traders who then transplanted it, step by step, as they marched westward across the Dark Continent in search of slaves and ivory. The Portuguese found it on the west coast of Africa, and carried it to the Canary Islands and from there to the New World.

Or consider the potato. The Spaniards found it in the highlands of Peru. Peruvians still depend heavily on the potato as a food staple; in fact, they have been importers

National Film Board from Black Star

On its way to become aircraft plywood, this Sitka spruce is opened up by two brawny fallers — part of the crew of Canadian lumberjacks who this year got out 200,000,000 feet of spruce on the Queen Charlotte Islands, 50 miles from Alaska.

in recent years, but by far the world's largest producer is Russia. The potato traveled from South America to Spain in the Sixteenth Century. When in the Seventeenth Century the Spaniards attained control of Flanders, they introduced the potato there. Thence it went to Germany. From North America it traveled to Britain and Ireland. By the time the industrial revolution was well under way, the potato — which is among the highest producers of calories per acre of any food growable in cool climates — was sufficiently well established in Europe to help feed her rapidly increasing populations.

Such stories can be repeated more or less ad infinitum. The rubber tree, native of the rain forests of South America, now flourishes over great areas of the East Indies and the Malay Peninsula. Quinine from the cinchona tree, which is a native of the Andes, is (or was) obtained mostly from the East Indies. We have imported the soybean from Asia, many varieties of livestock from Europe, fish from all over the world. The Pacific salmon, after extensive trials in many apparently suitable regions, has finally taken hold in a few streams in New Zealand and southern Chile. American cigarettes are now flavored with many tobaccos grown in regions which had never heard of the weed until well after Sir Walter Raleigh lost his head. Latakia from Syria is an example.

It will be recalled that when the gods descended from Mount Olympus to meddle in men's affairs, the results not infrequently were disastrous either to the recipients of their favors or to the more or less innocent bystanders. Man's tinkering with nature's balance doesn't always turn out so well either, as Australia spectacularly illustrates. Under a sudden influx of competition-toughened plants and animals from Europe and the Americas, that continent acted like an ecological vacuum. Wheat and wool, which produce much of Australia's wealth, are not native products, and many another importation has lived up to expectations. But on the other hand, the descendants of the domestic pigs which Captain Cook introduced into northeastern Australia with the most praiseworthy motives are now referred to as "Cook's curse," for they have pretty well devastated many sections between Cape York and Burketown. The prickly pear, which was imported to form hedges and act as fodder, forced out all useful vegetation over scores of millions of acres and was brought under control only by the most strenuous efforts. And, of course, the rabbit, which was brought in to give a little sport now and then, has practically taken over the country, influencing the pattern of Australian agriculture and even assuming geological significance, for so thoroughly has it destroyed vegetation in many arid regions that the topsoil has been loosened to become the prey of wind and water. As in some parts of the United States, the deserts are on the march in Australia, their way paved in part by the rabbit.

Electricity for Plywood

BY THOMAS D. PERRY

MANY of the improvements in the technique of making plywood have appeared from unexpected sources. For instance, the epoch-making resin adhesives did not come from gluemakers but were originated by a chemical manufacturer without background in either glue or woodwork. The process of molding plywood with flexible bags and fluid pressure originated in the rubber-tire industry, where outer casings were vulcanized under internal pressure. This molded, or *monocoque*, plywood has been of outstanding utility in the aircraft and boat program. Resin impregnation and compression followed the pioneer work in wood preservatives.

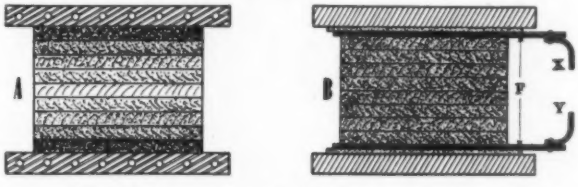
Another important contribution to plywood technique has now crossed the threshold, and this one came from the radio industry. Diathermy apparatus, the artificial fever machine which heats interior human tissues without burning the skin, is well recognized by the medical profession. Diathermy's counterpart, radio-frequency heat, is fast becoming an important heat source in industry. In the metal field, heating by induction at radio frequencies has been adapted to welding, tempering, annealing, and the like. In woodworking, radio-frequency heat gives distinct promise in the rapid heat-curing of the recently developed resin adhesives. Up to now there has not been a satisfactory method of heat application which would penetrate a thick wood block, through and through, both rapidly and uniformly.

In order to visualize the value of such an instrumentality as radio-frequency heat, a brief outline of the development of the new resin adhesives that are revolutionizing the plywood industry may be helpful. The older, conventional glues obtained their "set" chiefly by the rather slow evaporation of the solvent, and most of them were more or less resoluble when exposed to extreme moisture. The resin adhesives, on the other hand, are hardened by chemical action, usually activated by heat, although some types can be cured by chemical action alone. Resin joints

are highly resistant to water and are more durable than those obtained with any of the earlier glues. Experience has demonstrated that of the various types of resin adhesives, the hot-pressed phenol-formaldehyde resins give the most durable bond. For several years this type of resin bond has been required for Army and Navy aircraft. The best of such phenolic adhesive joints can be fully cured in five minutes by application of a temperature of approximately 300 degrees F. Lower temperatures prolong the time requirements, reduce the output, and may lower the moisture resistance of the bond by inadequate cure. Urea-formaldehyde resin adhesives have lower temperature requirements; with proper catalysts, they can be cured at 75 degrees F. Though the process is slow, it can be accelerated by heat. Urea resin bonds are less resistant to heat and moisture than are phenolics, though heat cures tend to increase their durability. These comments on resin adhesives add up to the fact that a hot-pressed phenolic resin bond which is cured at around 300 degrees F. gives the most durable glue bond for use in exacting service.

It is this fact regarding the optimum conditions of obtaining durability in resin adhesives which makes the consideration of radio-frequency heat so worth while. If the plywood is thin, up to a quarter of an inch thick, heat can easily be applied on the outside; penetration of the heat, while progressive, is reasonably fast, and the moisture balance between the surface and the interior of the plywood is not seriously disturbed. Hot-plate presses with steam-heated platens give satisfactory resin cures in plywood up to a thickness of about an inch, but the moisture unbalance becomes more serious as the thickness increases. When plywood is over an inch thick, the difficulties resulting from the application of external heat become rather complicated and the progressive variations in heat, moisture content, degree of cure, and compressibility are not likely to produce a reliable and uniform product.

A contrasting example is that of a wood assembly several inches thick, placed between electrode plates of a high-frequency field. With equipment of a suitable capacity, the temperature throughout the wood assembly is found to be amazingly uniform and to give a prompt heat cure to the adhesive bond between the layers. The speed of heat increase is dependent on the electric power available, and a proper control of variations in density and moisture content is desirable. The results that can be obtained with such heat effects in glued assemblies using synthetic resin adhesives are outstanding. Blocks 12 or more inches thick can be heated thoroughly and the adhesives cured in no longer than is required for quarter-inch plywood between steam-heated platens. The contrast in heat distribution between the two methods is shown in Figs. *A* and *B*. The former represents steam-heated platens and the latter a pair of electrodes producing a radio-frequency field. Two highly important industrial applications of such thick glued members are to the fabricating of heavy keels and ribs for ships and to the bonding of multiple wood laminations into heavy timbers for trusses, arches, beams, and so on, in bridges and roofs. Without rapid heat penetration, the most effective bonding is difficult to secure. Both of these industries bid fair to be large consumers of resin adhesives in the postwar years.



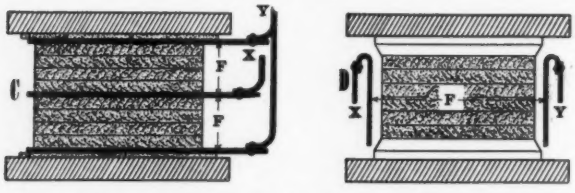
As has been noted, some resin adhesives can be cured at normal temperatures of 75 degrees F., but at such temperatures many hours of clamping are required, output is seriously retarded, and the amount of clamping equipment needed is greatly increased. With any given type of

Cut into veneers which are bonded into plywood, airplane spruce reaches its destiny in forms such as this, which will become part of a Mosquito bomber.

National Film Board from Black Star

resin, heat-cured bonds are generally more durable than those produced by the chemical reaction of catalysts, and the most durable types of resin adhesives have not yet been found to cure satisfactorily without the application of substantial heat.

The high-frequency field for such adhesive work is generated by equipment of the order of a small broadcasting outfit. Except for the larger units, which require a stationary installation, the equipment can generally be moved around the factory from job to job. The frequency of the electric field is usually between two and ten megacycles, although in some special cases still higher frequencies are used. Two methods of positioning the electrodes are shown in Figs. *C* and *D*. Wood assemblies may



also be clamped with metal strips, or plates, on both sides and next to the forms, or molds. Such thin plates are adapted to curved laminated assemblies. They serve as electrodes and have projecting terminals to which the high-frequency generator may be attached. With a series of such clamps, the movable generator can progress up the line without loss of operating time.

So far we have been concerned only with adhesive bonds between layers of wood or veneer. The use of heat produced by a radio-frequency electric field also serves an important function in wood assembly operations when a plywood covering, or skin, is to be affixed to ribs or spars as in an airplane wing, or when plywood is to be attached to the framework of houses or industrial structures. Here the electrodes may be of various shapes and at such location as to permit the current to pass through the glue line. Sometimes the two electrodes may be in a hand tool and applied to the outside of a thin plywood skin. The surrounding electric field is extensive enough to heat a glue line just on the inside of the plywood. In assembly joints the speed of setting is of prime importance in facilitating production and reducing clamping equipment. There again such electrostatic "spot welders" can be used to tack layers of molded plywood together temporarily.

All in all, radio-frequency heat offers a wide range of utility to the woodworker, and new discoveries are constantly widening its utility. Whether it is the all-purpose method of curing resin bonds is still a question, and how far it may be useful in a supplementary way to steam and electric-resistance heat remains for a later entry in the ledgers of industrial progress.

Science at War

THAT the war now racking the world is a war of science has been said so often as to need no repetition. The phrase is one of those inclusive categoricals which are so convenient and so inclusive as to be decidedly dangerous both to the statement they purport to make and to the terms in which they seek to make it. For this reason, George W. Gray's excellent *Science at War* * commands special commendation because of the fact that it establishes clearly the distinctions necessary to general recognition of the truth that though in this war as in all wars science is an arsenal of mighty weapons, though scientists now are arming the fighting man more powerfully than ever before, though war can be shown always to have been a great stimulant to research and effective employment of the results of research, the business of science nevertheless is not war. Mr. Gray tilts at no windmills, but he does both from the record of the past and from his temperate analysis of the present demonstrate succinctly that though science may be at war and should be at war, science is not intrinsically of war but rather is of peace and will in the decades after this war become a more vigorous thing of peace than it has had opportunity to be during its comparatively short course as a factor in human affairs.

* New York: Harper and Brothers, 1943. xi + 296 pages. $3.00.

Running the gamut from the Germans' magnetic mine, which was the first of the "secret weapons" of this conflict, to the developments in aeromedicine which promise to be among the most lasting of the secrets which it has revealed, Mr. Gray's book is necessarily packed with detail. To present such a mass of material only after the accuracy and authority of the myriad items had been established is no small accomplishment. To arrange and pattern the mass into coherent and easily assimilated order is perhaps an equal one. *Science at War* is in both these regards new evidence of its author's well-merited reputation as a reliable and skillful writer.

Of particular interest as they provide bases for suggestive speculation over the future are chapters dealing with mathematics as it has been applied in the war, with the development of new materials and of new techniques of using older materials, with war medicine and war surgery as apart from aeromedicine, and with the uses of psychological methods in the war of ideas. Readers of The Review who recall, in our issue for July, Mr. Gray's article discussing the military utilization of applied mathematics will find interest in the expanding of the story in this volume. Best counterbalance to the gloomy story of distortion and falsehood making up the technique of the war of ideas as Goebbels practices it is the recital of the arraying of medical and research skill which thus far in this war has given better than a promise of reducing the toll of death and disablement to a lower mark than has ever before been possible. Aeromedicine, with its studies of oxygen starvation, of the physiology of acceleration, and of the psychological effects of the nervous tension of flight, is obviously a discipline of tremendous importance for the future. The flying ambulance as a concrete physical thing is a vivid example of a new instrumentality in medicine; less immediately dramatic but of possibilities which presage influence in ways as yet undreamed are the new-found ideas, theories, and quanta of abstract knowledge of which this field is compact.

Progress Report

AMONG the characteristic events of the chaotic year which draws toward its close this month was the minor terrestrial cataclysm which attended the birth of a volcano in the Mexican state of Michoacán. Overshadowed in the news by social and spiritual upheavals of far more titanic force, the fiery cone of Parícutin has nevertheless since its emergence pegged steadily away at the job of being a model of efficient vulcanism according to classical standards. (*Concluded on page 114*)

F. S. Lincoln, '22

The Revolution at Kitty Hawk

What the Achievement of the Airplane Owed to the Past and Presages for the Future

By Fred C. Kelly

TODAY, 40 years after the achievement of sustained flight in a heavier-than-air machine, we know that unless we can organize the world to maintain peace, civilization may be destroyed. We hear that right now it is possible to build bombers capable of making nonstop round trips between Europe and America. Passenger trips to Europe between breakfast and dinner have become commonplace. If the airplane has created great danger to everyone in the world, it also has made evident the fact that somehow we *must* prevent future wars. We've somehow *got* to succeed — because the airplane leaves us no choice between world unity and chaos. Whatever happens, the airplane has already had a more revolutionary effect on world outlook than any other thing since the discovery of America.

Above:
The Wright Memorial on the dunes near Kitty Hawk, North Carolina

Regarded from the purely technical side, without reference to its effects, the airplane may be considered revolutionary in another way — from the manner in which it was invented, from the fact that it required fundamental discoveries. It was almost as if Orville and Wilbur Wright had started from scratch when they began the endeavor which reached successful consummation over the dunes of Kitty Hawk on December 17, 1903.

Nearly every great invention is largely a synthesis of principles already known. But that was not true of the airplane. Though many able men, including eminent scientists, had tried to design machines that could fly, and a vast amount of money had been spent in such attempts, the Wrights received surprisingly little technical help from the work of any of their predecessors. True, they did get *inspiration* from others, and they doubtless avoided much waste effort by learning what had come of earlier attempts

to fly. They came to have great respect for their predecessors, even for those who had made dismal failures, for no one knew better than the Wrights how great were the difficulties. They felt deferential toward all who had thought it worth while to try and to risk their lives in testing their theories. But the Wrights soon came to recognize which of their predecessors had been truly important.

Their greatest debt of all was to Otto Lilienthal, who had made gliding experiments from a hill artificially created for that purpose near Berlin. Reports which they read of Lilienthal's gliding first caused the Wrights to become seriously interested in human flight. Except for Lilienthal's experiments and what he wrote about them, it is doubtful whether the Wrights would ever have undertaken a serious study of flying. Lilienthal was the first of all the experimenters to have any understanding of why a cambered wing was more effective than a flat one — though many before him had *proposed* the use of cambered wings, simply because birds had them.

Even though it was Lilienthal who got the Wrights interested in trying to fly — and they freely acknowledged that their debt to him was great — yet in their first powered plane they used no technical device or data taken from Lilienthal. His tables of air pressures on curved surfaces had proved to be inaccurate. Not until after they had made their own compilations of air pressures, from wind-tunnel experiments, were the Wrights able to build the 1902 glider in which they virtually solved the problem of equilibrium. Both the shape of the wings in that machine and the method of control were conceived by the Wrights and by no one else.

The fact that the Wrights did not use much technical knowledge discovered by their predecessors seems to be contrary to a widespread impression. Since my biography of the Wrights appeared, I have had numerous letters from readers who evidently had thought that all the Wrights did was simply to go a little farther, in the same direction, than others had succeeded in doing. One letter — from a science editor — argued that I should have given more credit to Samuel P. Langley, onetime Secretary of the Smithsonian Institution, who had made costly attempts to build a successful flying machine. The Wrights did receive inspiration from Langley, and have publicly said so. It was encouraging to them to know that a great scientist, the directing head of a famous scientific institution, considered human flight possible. Beyond inspiration and encouragement, however, the Wrights got nothing from Langley. His scientific work itself was of no value to them. Published reports of his studies of air pressures dealt with flat surfaces only, and even those figures were inaccurate. No technical idea embodied in the Wright machine came from Langley. (It may be added that in no other successful airplane has any scientific idea original with Langley been used.)

One of the earlier experimenters whom the Wrights, from their reading, recognized as a man of great ability was Sir George Cayley. Early in the Nineteenth Century, he had formulated tables of air pressures and a system of control. His measurements of air pressures were made on flat surfaces only, and the Wrights made no use of them. But it was a source of satisfaction to the brothers to know that a man of Cayley's high standing had not considered it "crazy" to study the possibility of human flight.

Another early experimenter with whose work the Wrights were familiar was William Samuel Henson. He and another Englishman, John Stringfellow, built a model plane reported to have been flown in 1848. Although both of those men showed mechanical ingenuity, the importance of their work is sometimes much exaggerated. I have seen a statement, in a letter from a writer on scientific subjects, that "Henson had conceived about everything the Wrights had, except the important twisting wing tips. Launching, propulsion, sustention, steering, and control — all were pretty much anticipations of the Wrights." Such a statement is nonsense. The truth is that the most Henson contributed to the flying art was the structural design of his wing ribs, which had an upper and lower strip of wood fastened together at the front and rear ends, with blocks between them at intermediate points. In that way he got a light rib of considerable thickness and stiffness, with sharp front and rear edges. To obtain the desired thickness and stiffness at the center, Henson built his wings with a slight curvature, or camber, but not because of any knowledge that cambered wings were more efficient than flat ones. Evidence can be produced to show that Henson was unaware of the aerodynamic value of camber. His knowledge of aerodynamics was only what he got from Cayley, and Cayley considered plane and cambered wings equally good (*Nicholson's Journal*, November, 1809). Stringfellow likewise lacked knowledge of the value of the cambered wing. A proof is the fact that in his last model (his triplane of 1868) he used flat wings.

Henson's rudder — as his patent states — was for the purpose of steering. The rudder on the Wright machine, however, was for lateral balance. (Adding a rudder to a flying machine to steer it, as does the rudder of a boat, would not constitute invention unless by such means a new effect was produced. The rudder in the Wright machine was patentable because it did create a new effect, not produced by a ship's rudder. In the oral decision of the Supreme Court of Germany, in a Wright patent suit, the chief justice said the Wrights would have been entitled to a patent for the rudder of an airplane, even if the plane had no ailerons, had they applied for such a patent, because all parties to the suit admitted that the airplane rudder was a balancing device, not a steering device, and that the Wrights were the first to discover it as such.) Henson did not provide any means for maintaining the lateral balance of his machine, not even the dihedral known to Cayley. He knew nothing of the function of the airplane rudder of today.

Clever as was the work of those early builders of model airplanes, it should be made clear for the historical record that they were a long way from accomplishing the miracle of human flight. Those flying models were wonderfully ingenious toys and they gave both inspiration and hope, but they by no means proved that it was possible to build a machine that could fly and carry a pilot. A 10-year-old boy can build a small Pénaud helicopter and fly it, with no power except that of a twisted rubber band; the best engineers cannot follow the same design, on a scale large enough to lift a man, and make the machine fly.

There is no gainsaying that in their machine the Wrights used devices that were already well known. For example, they adopted superposed surfaces, which had been used by Wenham and later experimenters. (Indeed, the principle had been proposed long before Wenham's time by a minister of the gospel, the Rev. E. J. Cordner, and it had been used in Chinese (*Concluded on page 96*)

Smoke, but No Fire

How Science, Industry, and the Army Co-operated to Develop a Notable Method for Smoke-screening Targets

By Alden H. Waitt

AIRPLANE factories, munition works, power stations, railway centers, bridges, and similar installations are important and legitimate targets for long-range bombardment airplanes. Antiaircraft artillery defense has progressed to such an extent that, in order to prevent excessive losses, attacks on such objectives are generally made at night or at extremely high altitudes. On moonlight nights, however, trained bombardiers can hit such targets even when they are blacked out, and with the aid of flares can locate them when there is no moon. Smoke has been used by all the combatants in this war to prevent aerial observers from picking out these targets. Unless lights are showing on the ground, the smoke need not obscure completely. It is effective if it scatters or absorbs enough of the reflected light of the moon or flares to make ground features unrecognizable.

One of the most widely used methods for producing the extensive smoke screens required to protect vital points in areas back of the front has been the partial burning and distillation of low-grade fuel oil in smoke generators similar to the orchard heaters and smudgepots used in California fruit groves. These oil smokepots produce a dark gray smoke which is effective but expensive in men and material. When they are in use, the smokepots must be serviced frequently, almost every hour throughout the night; operating them requires many men; and they provide little or no protection if used during the day. There are other methods for making smoke, each having advantages and disadvantages, but all falling far short of screening requirements for large areas.

Early in the spring of 1942, the officers concerned with chemical warfare research and development realized that a more efficient method for producing large quantities of smoke had to be devised. Smoke had been found to provide one of the cheapest and most effective means of preventing enemy bombers from hitting vital targets in rear areas. Indeed, no successful bombing of an area protected with smoke has yet been recorded.

Co-operating very closely with the Army Service Forces is the National Defense Research Committee of the Office of Scientific Research and Development, of which Karl T. Compton, President of Technology, is a member. Many important and spectacular developments have resulted from the pioneer research of this committee. To them was presented the problem of finding the best possible kind of smoke. The result of this request is an outstanding example of the splendid co-operation existing between our civilian technical organizations and our military. It is not merely an illustration of teamwork among the scientists of the N.D.R.C., the technicians and engineers of industry, and the officers and men of the Chemical Warfare Service of the Army Service Forces, but is also an example of how even during the stress of war an abstract, theoretical idea may in a relatively short time be worked out and developed into a final piece of war equipment of decided effectiveness in the field.

Prominent in the work of the N.D.R.C. and internationally renowned as a distinguished scientist is Irving Langmuir, Nobel Prize winner and associate director of the General Electric Company's research laboratories in Schenectady, N. Y. Dr. Langmuir and his associates were asked to produce the ideal smoke. He attacked the problem from the point of view of pure science. He marshaled his formulas, made his calculations, and concluded that size, color, and density of the smoke

Photo by United States Army Chemical Warfare Service

A smoke-generator company carrying out a lateral screening mission, using the new generators which produce an effective smoke through the breaking up of a special oil by steam

Photo by United States Army Chemical Warfare Service

The M1 mechanical smoke generator in action

particles determine the effectiveness of any smoke. Of these factors, size seemed to be the one on which he should concentrate.

A screening smoke is a cloud of extremely small liquid or solid particles suspended in the air. A smoke screen accomplishes its purpose by scattering rays of light through reflection caused by the many individual particles suspended in the air and also to some extent by actual obstruction of the light rays. The scattering of light rays by smoke particles depends upon the number of particles in a given air space. According to Dr. Langmuir, the particles must be of a certain specified size to have greatest effectiveness. Having arrived at the theoretically ideal particle, he next had the task of building a generator that would produce a smoke to fit the specifications he had established. He assigned this problem to Vincent Schaefer, his assistant. Schaefer, working in his laboratory at the General Electric Company, made a number of models before he found one which seemed to produce a smoke particle that met the theoretical specifications of Dr. Langmuir. This he tested in a large "smokebox," from the top of which he could look down through his smoke screen upon various colors and shapes in much the same way a bombardier would look through a cloud set up over a ground target. The machine was now ready for the pilot-model stage; this job was allotted to the Standard Oil Development Company on a research contract.

Here we have applied science coming into the picture. Pure science in the persons of Dr. Langmuir and Vincent Schaefer had determined the specifications for and the nature of the ideal smoke and had worked out a scheme for producing it. Applied science through the medium of Standard Oil was to build a smoke machine which would produce vast clouds of a smoke of the given specifications.

Dr. Langmuir had been given his directive in early spring. The solution of the problem had taken him only a few weeks. Of course, he had given some thought to this subject before, and perhaps had devoted study to similar projects. The specific problem, as defined by the Chemical Warfare Service and the National Defense Research Committee, however, was first given to him some time in February or March of last year. He was ready to have his theories applied by the end of April. He held conferences with the engineers of the Standard Oil Development Company from May 2 to May 5, 1942 and with them established certain factors having to do with the capacity and design of the equipment.

The design of a unit which would produce smoke by breaking a special oil down into tiny particles by means of steam began immediately. One month later the first smoke generator unit was completed, and in June the unit was tested in Schoharie Valley near Schenectady. These tests were witnessed by representatives of the Army, the Navy, the N.D.R.C., the National Research Council of Canada, and several industrial companies. Soon thereafter the equipment was transferred to the home station of the Chemical Warfare Service at Edgewood Arsenal, where it received its final tests. These were so successful that a commercial contract was immediately let to the Heil Company at Milwaukee, Wis., to manufacture the smoke generator unit in quantity. The first unit came off the production line quickly, and final tests and inspection were completed on July 24. The National Defense Research Committee had received the problem, turned it over to Dr. Langmuir, who had done his share and turned it over to industry so that in less than six months a machine had been devised which was many times more effective than the early smoke oil-burners and was the best large-scale smoke producer ever developed.

The story is not yet complete. Smoke generator test companies were formed and equipped with the new machines. They were sent to Cape Cod to work with the amphibious units then in training, and by the end of the summer these units with the new mechanical smoke generators were sent overseas to Casablanca, where they went into active operations. This was truly a triumph of co-ordinated research, development, manufacture, organization, and training — the wedding of pure and applied science. Since that time, many chemical smoke-generator companies have been activated with the M1 mechanical generator as the standard equipment. A number have been sent to our active theaters. Reports have been made of the splendid service these companies rendered in North Africa and Sicily. Many more are in training in this country.

The M1 mechanical smoke generator which resulted from Dr. Langmuir's research actually produces a dense white fog instead of a smoke. This fog is almost odorless and, unlike smoke from the earlier generators which partially burned oil, contains no sooty particles and therefore does not stain or deposit carbon on surfaces with which it comes in contact. This fact is important in a thickly settled community. The screen is produced by the steam distillation of a special petroleum product. The resulting fog or smoke is made up of droplets which are uniform in size and of extremely small diameter. Their size conforms to the specifications set by Dr. Langmuir.

The machine has a source of power for driving the hot liquid and steam through spray nozzles. Water, fuel, and the compound to be sprayed are carried in large tanks. All of this is mounted on a base which can be carried on a trailer, a barge, or a truck, or can be placed on the ground in a fixed position.

The smoke has a very high persistency. Clouds which have been generated from a single line of generators have been observed a good 20 miles downwind, hanging together all the time and giving an obscuring screen for at least half the distance. Previously, 10 miles had been considered an extraordinarily long distance for any smoke cloud to travel.

The length of the cloud travel with generators of this type makes it possible to cover landing fields and large industrial areas in such a way and from such a distance that the enemy has no aiming points relative to the target which he may use successfully in directing his bombs. A small smoke screen might well serve to call the attention of the bombardier to a target and to delineate it for him. The screen from the M1 mechanical generators covers such tremendous areas, especially when several lines of them are used, that the enemy has practically no chance of hitting a vital point. One of the recent reports received from overseas quotes a conversation between two enemy fliers in the air over North Africa. In the conversation, one flier said to the other: "There's no use trying to bomb your objective. It's covered with that damned smoke."

It is easy to imagine the difficulty that the bombardier is faced with when he finds himself over a target covered with smoke for many square miles. He must either drop his bombs indiscriminately in the smoke with a faint hope that they will damage an important installation in the area, or he must find some other location that is uncovered. The choice is not an easy one. If a pilot has come several hundred miles with a mission of bombing a power station or an oil refinery and he knows that the target is somewhere within the area of the smoke, he may be inclined to take a chance and hope his bombs will reach a profitable objective. An alternative target which may have been assigned might also be screened, or it might be protected by powerful fighter planes or by heavy anti-aircraft artillery defenses.

Our American theory of bombing lays great stress on accuracy. Our air force believes and is proving daily that our bombardiers can hit their targets a reasonable percentage of the time. We don't like to try to hit something we can't see. We believe that point bombing is more profitable than area bombing. Smoke properly placed makes precision bombing impossible. "If you can't see 'em, you can't hit 'em."

In the daytime, the screen is wide enough and high enough to cover not only the vital point but also most landmarks or aiming points. At night a dark-colored screen not only obscures a target but has a valuable camouflage effect. From a high altitude, a gray smoke, even in the moonlight, has the appearance of a body of water. The pilot or the navigator, seeing what looks like a large lake where he had expected to see no water, is confused. Regardless of the camouflage effect, however, the smoke screen is obscuring. Although airplanes can look behind a smoke screen, they cannot look under it.

The tactics of smoke-screening large areas are being developed rapidly, and although each area to be obscured must be treated according to the peculiar conditions of wind, weather, and terrain existing in that particular place, there is a general method of procedure that has been carefully worked out. Generators will ordinarily be stationed at selected points to the windward of the place to be screened and will be moved if the wind shifts. In case of an air-raid alarm, the smoke blanket will be started from generators close to the vital point, the distance depending upon how hard the wind is blowing. A second line of generators will commence operation 400 to 500 yards to windward. As their smoke reaches the point that must be protected, the close-in generators will fan out to previously selected positions still farther to windward.

The standard burning-type smokepots which produce smoke clouds immediately are used to start an initial screen while the generator is (*Concluded on page 96*)

Drifting and clinging, the smoke produced by the Chemical Warfare Service's new generators blankets an area in tests.

Photo by United States Army Signal Corps

Today's Airplanes Tomorrow

Sound Plans for Peacetime Handling of Wartime Transport Fleets Are Essential to Safeguard the Industry and the Nation

By L. Welch Pogue

TRANSPORT aircraft are a vital national asset today. As a nation, we woke up late to the fact that this is an air war. In some respects, we woke up still later to the crying need for transport aircraft. There are those who still stoutly maintain that the principal war use for the transport aircraft is to carry air-borne troops and task-force equipment to the field of battle. But do we use the 150,000 miles of air transport routes, which are operated by and under the direction of the armed forces today, to carry only parachute troops and ammunition? The fact is that the planes which fly these routes carry, just as our merchant marine does, a great variety of what is needed, and constitute a line of fast communication generally, which is indispensable to modern war. Apart from this vast military air transport service, the drastically curtailed fleets of our commercial carriers still operate some 110,000 miles of regular routes gorged with the vital traffic generated by an expanded war economy. Many keymen went from these commercial air lines to join the Air Transport Command and the Naval Air Transport Service, where they have helped to build up the globe-encircling routes which I have mentioned.

Because as a nation we had not foreseen the vital war need for transport aircraft, we were late in starting to supply that need. Now we are under way. By the time we have won this war, we shall have a vast air transport fleet and vast air-transport production capacity.

The possession of this great machinery of war in peacetime, however, may prove as big a problem as the lack of it proved at the outset of the war. Let us not be caught flat-footed a second time. Unless we make wise plans in advance for the peacetime handling of this wartime fleet and this wartime capacity, our progress in air transportation and aircraft development may be arrested for a decade. The government alone can take effective action, for the principal reason that it will own the airplanes which create the problem.

If there is no planning, and if the surplus aircraft on hand at the end of the war are simply peddled to the highest bidder, we may be reasonably sure of the following consequences: (1) A vast and costly defense reserve will have been wasted; (2) the transport aircraft market will be glutted for years to come; and (3) the capacity to manufacture and develop transport aircraft will suffer a blow from which it will take years to recover. This last consequence would be the gravest by far. The possession of a static reserve fleet of several thousand transport aircraft in condition to fly provides only short-term defense insurance. No other instrument of war or peace becomes obsolete so fast as an airplane. Aviation preparedness for either war or peace can be represented only by the power and capacity to supply continuously new and improved aircraft.

Before discussing machinery for the handling of the war air transports we shall have on hand at the close of hostilities, I should first like to place in broad perspective the magnitude of the surplus aircraft problem with which we shall probably be faced. Aircraft manufacturing capacity has had meteoric growth in the United States during the last two years. It was a relatively small industry in 1941. In that year, manufacturing production of automotive equipment reached the $3,700,000,000 mark, and aircraft manufacturing in dollar volume was way down the list. In 1939, the latest year for which comparative statistics are available, it was only 44th in importance among our industries. It is a twenty billion dollar industry this year. Next year it promises to be approximately a thirty billion dollar industry. If next year's promise is fulfilled, the industry will be more than eight times as large as the automobile industry was at its all-time peak.

This enlarged industry is now directly employing over one and one-half million people. It would probably be impossible to ascertain accurately the additional number who are contributing indirectly to the production of raw materials required for the manufacture of aircraft and engines, but we can be sure that the figure is several million. The older aircraft companies, after tremendous expansion, account for about three-fourths of the persons directly employed today. The remainder are those employed by automobile and other companies which are helping out in the aircraft production program.

The first questions that occur when we reflect on the problem of surplus aircraft are: How many aircraft and what kinds of aircraft are we talking about? Combat planes can largely be eliminated from consideration because most of them will not be available for sale or disposal on the open market. Although some bomber types could perhaps be converted for transport operation, this would be a costly and inefficient undertaking. Further to increase in this fashion the large surplus of transport aircraft which will surely be on hand at the war's end would be "carrying coals to Newcastle" with a vengeance. The principal kinds of aircraft we are talking about are the transports and the smaller types of planes used for training, courier service, and the like.

The public has been told of the production goals of about 90,000 aircraft in 1943 and about 125,000 in 1944. These figures represent gross tonnage of approximately 425,000 for 1943 and 638,000 for 1944. In view of the tendency to shift to larger types, tonnage is more realistic than number. The exact fractions of these totals which are combat planes, transports, bombers, and so forth, are not publicly known. It seems reasonable to estimate, however, that present schedules will call for the production of approximately 15,000 transport aircraft for a current year. These will include some smaller planes.

War is a hard master. Many aircraft already produced or to be produced will not appear in the final inventory. However, in terms of peacetime civil air transportation, by any method of estimate, the number will be very large. In 1940, United States output of aviation gasoline for all purposes was approximately 619,000,000 gallons. Under the normal peacetime standards of aircraft utilization, this gasoline would be sufficient to operate only approximately 2,000 of the sort of planes which would be represented by our war surplus. This rough measure should afford food for sober thought upon any proposition to maintain in continuous operation large numbers of transport aircraft which are markedly less efficient in the use of gasoline than would be new types designed to take full advantage of latest developments in aircraft and engine design and improvements in aviation fuel.

The war has, of course, provided a fabulous laboratory for the development of aviation in every respect. The best of our engineering talent has been assembled and given the green light. This focusing of talent in the engineering and development laboratory of modern war means that progress is made not by the year, the month, or the week but by the day, the hour, and even by the minute.

Assuming the very best possible job to have been done by the Army and the Navy in their specifications and designs, all the aircraft that will have been produced by the summer of 1944 will be obsolete as compared with those which incorporate all of the known developments and improvements then available. Not only would it be possible now to design and build an airplane more efficient than any pre-war type; it would be possible to improve on every plane now being built. That is no one's fault. It is the price we pay for progress. It is a cheap price when the value of improvements is considered. But it means that probably every plane in the category of surplus transport aircraft at the end of the war will, even if otherwise in good condition, be obsolete in terms of what our factories are then capable of producing. Or perhaps I might better say, what our factories *should* then be capable of producing. I shall mention this distinction later. At the moment, I suggest that the state of preparedness of our factories for peacetime production at the war's end should have a most important bearing upon the whole problem of working out the most efficient disposition of surplus transport aircraft.

A closely related factor is the need for an intelligent program of tapering off production at the close of the war. In all probability the aircraft manufacturing industry will still be running at high volume, and the surplus of aircraft will inevitably be increased by some unavoidable further production. We shall indeed be derelict, however, if we do not exercise the greatest care and wisdom toward preventing needless swelling of the formidable surplus which will already be on hand.

As I have previously indicated, the lack of a well-worked-out plan for coping with the surplus aircraft problem would doubtless result in the government's following the traditional policy of knocking down all surplus equipment to the highest bidder, with consequent saturation of both domestic and foreign markets. In addition to the unhappy consequences upon the manufacturer of flying equipment and the economy of the country in general, the result would prove anything but a boon to the United States air transport industry. This industry's health cannot be predicated upon tomorrow's use of today's airplanes. Its future growth, like its past growth, is intimately linked with the uninterrupted development of new and increasingly more efficient aircraft.

Nor would it be wise to dump these aircraft on the foreign market indiscriminately. Being a nation of outstanding excellence in transport aircraft manufacture, we shall be overlooking an important consideration if we do not weigh carefully how our own interests dovetail with those of foreign countries, and then make the necessary adjustments. Our own good reputation as the vendors of efficient aircraft might be protected better by some kind of a program which would make surplus aircraft available to meet temporary requirements pending the time when more efficient aircraft become available for purchase. This plan would keep the market fresh and vigorous.

As an alternative to dumping, the surplus aircraft might be scrapped. Of course, some would need to be preserved to take care of the immediate and pressing needs of United States and foreign carriers. Scrapping would have the advantage of preserving the available market. It would have the obvious disadvantage of liquidating a very large and costly fleet which might serve for a while as a valuable war reserve or as an instrument in the maintenance of peace for a number of postwar years. At this time no one (*Continued on page 98*)

Official photograph, United States Army Air Forces

A transport plane being loaded—present power which demands forethought for the future

Industrial Building Trends

Factories and Plants Must Be Calculated for the Work to Be Done in Them; Thus Economy Is Assured

By Herbert S. Swan

TO be geared for the maximum progress, every city must have not only efficient labor, efficient machinery, and adequate facilities for transportation, but also modern, up-to-date factory buildings. Housing the latest machinery in an antiquated structure is an anachronism, and achieves but a fraction of the maximum potential progress immediately possible in industry. The plant, instead of becoming a pacesetter in its particular line, remains a marginal or a near-marginal unit in the industry. The task challenging the industrial leaders of a community, therefore, is nothing less than the elimination of all waste and obsolescence in the economic structure, whether it may involve the retraining of personnel in industry to new skills, the installation of up-to-date equipment, or the construction of new factory buildings.

If cities are to equip themselves for the highest standard of living now possible and within reach, the great number of worn-out machines as well as the century-old buildings housing them must be replaced with the best available; otherwise, the great social gains made by labor during the past few years will prove wholly abortive. Unless as many units of goods are produced at no greater cost in a 40-hour week today as were produced in a 50- or 55-hour week several years ago, there has been not social progress but social retrogression. To progress we must produce more units at less cost. Not to do so means that we are slipping either into a static or into a permanently lower standard of living. Any improvement in method or equipment by a competitor must eventually be accepted by all if they are to survive. Every community has a huge problem of industrial rehabilitation upon its hands if it is to place its industries abreast of the present technological advance. In the average city no other phase of this problem is more difficult than the financing of the construction of satisfactory manufacturing plants.

Until comparatively recently, the productive machinery of an industry was fitted to the building housing it. The building was constructed first; equipment was adapted to the limitations of the building. In the best practice today this procedure has been changed. Now emphasis is placed not so much upon the building as upon serialization of the several manufacturing functions carried on under the roof — articulation and grouping of departments, reception and routing of materials through various fabricating processes in straight-line production, and the shipment of finished goods — so that the over-all cost of manufacture may be reduced to the lowest possible figure. Light, air, ventilation, wholesome working conditions, freedom from obstructing columns, interchangeability of floor areas within the building, possibility of expansion of operations without disruption of the organization, and every other consideration which reduces unit costs and speeds output have become objects of primary importance to the design of factory buildings. Under such conditions, is it surprising that the purchase or lease of almost every ready-made plant is scrutinized from the point of view of second-rate layout, or that old plants should possess practically no resale value?

In certain industries the change in demand for products has made it impossible to produce new products in older mills. In so far as depreciation and obsolescence are concerned, the old mills could be used for many, many years to come in making the old products, but the demand for new types of products by consumers has necessitated widespread scrapping of the old plants and the construction of new ones. Moreover, new buildings in many industries may be demanded more by the changing technique in manufacture than

General Electric Company

By night, an industrial plant is a dramatic focus of energy.

by the pressure of increased demand for additional products, but that fact does not make an efficient plant any less desirable. If the mechanism could be devised for financing construction, the engineering advances made in plant design would frequently be found to effect such economies in production that a given over-all capacity could be obtained at an appreciably reduced cost per unit. Large-capacity equipment, requiring less floor space per unit of productive capacity, effects a substantial reduction in heating, maintenance, operation, as well as repairs; improved illumination and modern methods of handling materials and goods so improve the efficiency of personnel as to lower labor costs. In other words, a plant which takes advantage of available improvements soon pays for itself out of savings.

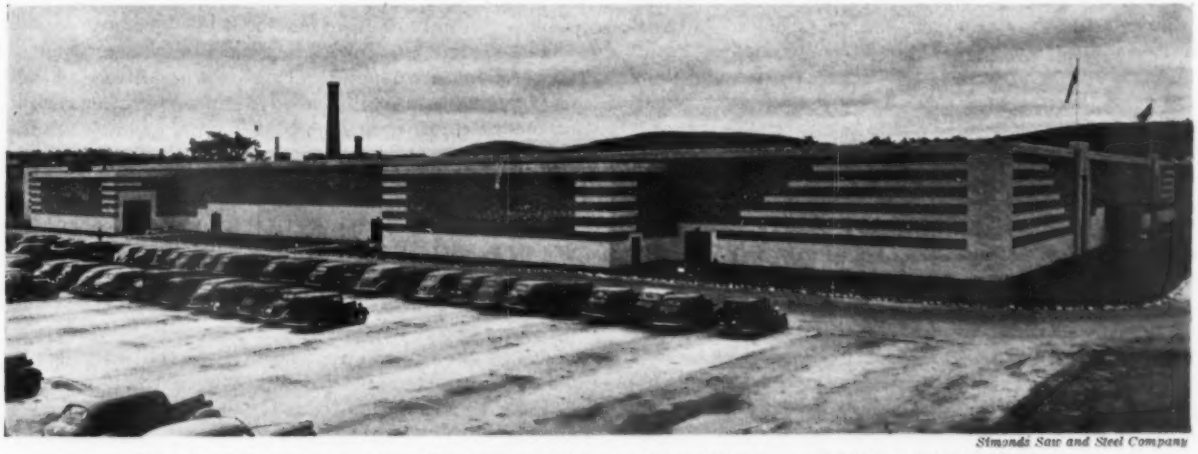
The trend toward one-story factory buildings emphasizes the importance of a spacious plot in an open area with low land values. To obtain adequate daylight illumination through either saw-tooth, monitor, or belt windows, a low building must be surrounded with ample open space. If it is flanked with other buildings, these too must be low or else they will appropriate to themselves light desired for the low factory building. Low land values are essential no less for minimizing capital investment in fixed assets than for keeping down annually recurring taxes on real estate. Frequently the need for parking many hundred and sometimes even several thousand cars also places a premium upon a location with low land values.

Desire to obtain efficiently designed buildings is attracting many industries to communities which, until a few years ago, would have been considered ineligible for such purposes. Whatever the shortcomings these communities may possess, the disadvantages are more than compensated for by the economies resulting from more satisfactory buildings. This is really an understatement of the situation, for as a result of the automobile, the truck, and the airplane, many communities in rural areas and on the peripheries of large cities are today really the most desirable locations, whereas at one time they would have been considered submarginal areas because of transportation problems. Frequently it is the central portions of our cities and not the sparsely settled suburbs surrounding them which constitute the present submarginal areas for industry.

A few years ago nearly every city was concerned with the need for incubator loft buildings, and as a result many multiunit loft buildings were erected for small organizations in the heart of a city. Though many of these proved successful and are still useful buildings, they have by no means served all of the building needs of small plants. Since these were, as a rule, multistory buildings, the elevator problem in them often became acute. In the unloading of raw materials and in the shipping of finished goods, considerable time was lost as a result of elevator congestion. Strikes in one loft often spread to other lofts. Labor disturbances affecting elevator operators, engineers, and persons engaged in other services frequently embarrassed and even paralyzed the satisfactory operation of the plant. All ground being covered with buildings, cars of employees could not be parked upon the premises, and parking was prohibited in the streets because of their narrow width. Moreover, if additional space were needed for expansion, the plan and present occupancy of the surrounding floor space made such changes either impracticable or impossible. When an occupant of a loft sought new quarters, he often found that it was just as easy to roll his machinery and equipment 50 or 100 miles away to a neighboring city as across the street or a block away within the same neighborhood. It is not without reason that loft buildings have lost in popularity with all concerned — the occupants, the owners, and the community.

Such considerations are leaving their impress not only upon the design of new industrial buildings but upon the scrapping of old structures. They frequently effect migrations of industry. At the time an organization junks an old plant, it carefully reviews the desirability of maintaining operations at its present location. To be successful, a 100 per cent plant demands a 100 per cent location. Erection of a new plant, therefore, frequently synchronizes with the removal of an industry to a more economic location.

The capital financing the construction of loft buildings is usually advanced by speculative interests dissociated from the industrial operations carried on within the buildings. Hence construction of loft buildings is unlike that of ordinary factory buildings which are commonly built for owner occupancy. In background, the erection of lofts is, indeed, less similar to the (*Continued on page 104*)



Simonds Saw and Steel Company

Precision work is done in self-contained production lines in the single five-acre room of this windowless factory.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

For the Future

SPECIFIC objectives to be considered for development in the future, and the philosophy of transition from intensive research and training for war to the purposes of peace when the Institute's responsibilities in the present emergency have ended, were discussed in the second part of President Compton's report to the Corporation, summarized below. From the activities of the past year, described in The Review last month, Dr. Compton turned to prospects of the future and the opportunities suggested by recent technical developments.

He directed special attention to applied mathematics, a field in which the Institute has always been strong, both in its Department of Mathematics and in its related engineering and scientific Departments. "Even before the war," said Dr. Compton, "there was a growing nation-wide movement to strengthen applied mathematics. As part of this movement, we set up an interdepartmental staff committee to promote the development of this field and set aside an initial sum of $10,000 to provide a limited number of postgraduate or postdoctoral fellowships. As a further move, the Executive Committee has recently set aside $25,000 to be used as circumstances permit to increase the Institute's opportunities and effectiveness in applied mathematics."

Turning to other fields, Dr. Compton continued: "Without knowing much of the detail, the public is well aware that remarkable progress has been made, under the stimulus of the war, in the theories and useful applications of electronic tubes and associated electrical circuits, which are generally and somewhat loosely described by the term 'electronics.' This has been for some years an important activity in our Departments of Physics and Electrical Engineering. It is evident that this field is rapidly growing in importance and that the Institute has for various reasons a unique opportunity to play a leading role in its further development. In order to insure our ability to take prompt steps in this matter as opportunities arise, the Executive Committee has recently set aside an initial sum of $50,000.

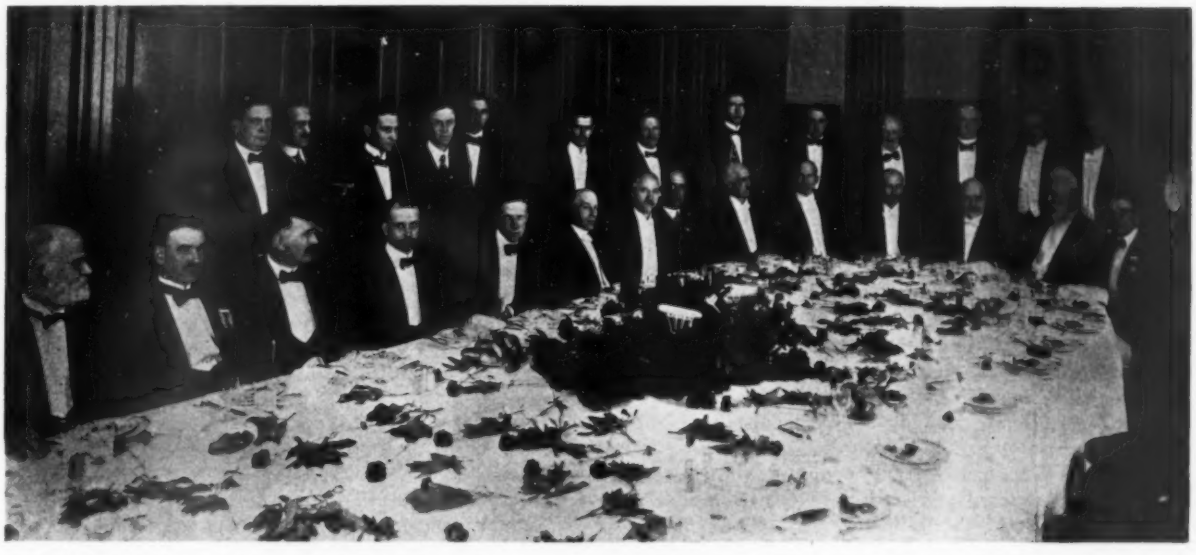
"The ingenious design of special instruments along sound engineering lines is partly dependent upon native ingenuity and partly upon sound scientific and engineering training. Because we are the type of institution which we are, and because we have been unusually fortunate in having on our staff individuals who combine native ingenuity and sound training in a remarkable degree, one of our lines of notable achievement has been the invention and development of instruments. In fact, we have been given both moral and practical encouragement from a very important governmental user of highly technical instruments, in order that we may serve as a still more effective center for developing instruments and for training instrument designers. As a step to promote further progress, the Executive Committee has recently set aside the sum of $25,000, again to permit prompt action on new opportunities in this direction. Furthermore, we plan in the near future to assign to an interdepartmental group the responsibility for the further development of our educational program in this highly important field, which is on the one hand specialized but on the other hand very wide in the scope of its applications.

"Several recent Visiting Committees of the Corporation have emphasized the rapidly growing importance and scope of organic chemistry, both in its theoretical developments and in the multiplicity of its important industrial applications. We certainly have no need to be ashamed of our past record or present position in organic chemistry, which has been and is now one of the important branches of our undergraduate, postgraduate, and research work. However, the opportunities that have been emphasized by our Visiting Committees are so real as to justify, in my opinion, a special effort to strengthen still further this aspect of our program.

"The M.I.T. established the first Department of Architecture in the United States, and it has been one of our finest in its background of prestige and usefulness. During the past dozen years the problems of architecture and of architectural schools have been complex and difficult. It was one of the professions hardest hit by the depression. This obstacle, followed by the war, came just at the time when the Modern, or functional, architecture appeared in the field as a competitor with the more classical point of view. Though the exact outcome of this competition cannot be predicted, it is abundantly clear that the new movement is having a profound effect upon architectural thinking and practice. The trends emphasize the value of a technological environment around an architectural school. Pertinent to the situation is the fact, established by the National Roster of Scientific and Specialized Personnel, that the average age of professional architects in this country is higher than that of the members of any other profession. Just what the significance of these facts may be in guiding the further development of our School of Architecture is not entirely clear, but the problem certainly requires careful study.

"The Visiting Committee on the Library, the Faculty Library Committee, and the Friends of the Library have independently and jointly called attention to the cramped and inappropriate quarters of our Central Library and to our need for a well-planned, conveniently located, and properly appointed library building. The growth of the Institute and the importance of its Library demand that this new facility be on the 'must' list of postwar projects.

"In several previous reports I have called attention to the desirability of more adequate provision for living and recreational facilities for students. To some extent the objectives there set forth have been realized through actions by the Corporation and through the generous response of the Alumni. Of outstanding importance have been the acquirement of the Graduate House and the construction of the Alumni Pool, Briggs Field House, and track facilities. It is an exceedingly fortunate coinci-



Notable among the festivities connected with the Institute's removal to its Cambridge quarters 27 years ago was a dinner in honor of Orville Wright, given at the Engineers Club in Boston on June 12, 1916. The plane which Dr. Wright and his brother Wilbur had used in their conquest of the air 40 years ago this month was exhibited when the Institute's new home was opened. This photograph was made available to The Review by Lester D. Gardner, '98, President of the aeronautical archives of the Institute of the Aeronautical Sciences. Those present, with the positions they then occupied in the world of science and engineering, were as follows:

Seated, left to right: *(1) John Ritchie, Jr., M.I.T., publicity; (2) C. P. Page, Van Blerck Motor Company; (3) Arthur E. Kennelly, Professor of Electrical Engineering, M.I.T.; (4) Edwin B. Wilson, Professor of Mathematics, M.I.T.; (5) Philip J. Roosevelt of New York; (6) James P. Munroe, '82, Secretary of the Corporation, M.I.T.; (7) Godfrey L. Cabot, '81, President, Aero Club of New England; (8) Paul W. Litchfield, '96, President, Goodyear Tire and Rubber Company; (9) William E. Byerly, Professor of Mathematics, Harvard; (10) Rear Admiral Washington Lee Capps, chief constructor, United States Navy; (11) Orville Wright; (12) Cecil H. Peabody, '77, Head of the Department of Naval Architecture and Marine Engineering, M.I.T.; (13) Alexander Graham Bell; and (14) Edward M. Hagar, '93, President, Wright Company.*

Standing, left to right: *(1) J. H. Barbazette, Wright Company; (2) Lester D. Gardner, '98, publisher,* Aviation; *(3) A. Roy Knabenshue, pioneer airship pilot; (4) Joseph C. Riley, '98, Associate Professor of Heat Engineering, M.I.T.; (5) Raymond Ware, Thomas Motor Car Company; (6) Thomas H. Huff, '15, instructor in aeronautical engineering, M.I.T.; (7) Alan R. Hawley, President, Aero Club of America; (8) Glenn L. Martin, Glenn L. Martin Company; (9) Oscar Brindley, holder of the Curtiss Marine Flying Trophy; (10) Robert W. Willson, Professor of Astronomy, Harvard; (11) Arthur G. Webster, Professor of Physics, Clark; (12) Jerome C. Hunsaker, '12, assistant naval constructor, United States Navy; (13) James Means, publisher, "Aeronautical Annual," 1896–1899; (14) Alexander Klemin, '16, instructor in aeronautical engineering, M.I.T.*

dence that these added facilities were secured before the war, because without them it would have been utterly impossible for us to undertake anything comparable with our present program of co-operation with the Army and Navy in their special training programs, for which housing and recreational facilities have been absolute requirements. Useful as these recent acquisitions have been, much remains still to be achieved before we can present to the student and his parents a situation that is actually, as well as competitively, in reasonably good balance with the more strictly educational and professional opportunities which are available here. I hope very much that means may soon be found to carry out those parts of this program which are still notably lacking in providing for our students a fully healthy and inspiring environment.

"The foregoing list of special subjects for postwar planning is not intended to be exhaustive. There are many other points deserving special attention, many of which have been suggested by and worked upon by members of our staff. In fact, there is no aspect of our activities which should not soon be carefully examined in order that our over-all use of facilities of staff, funds, and equipment may be attuned to the technological opportunities and trends of the times in such manner as to make Technology the most effective agency which it is in our power to achieve within the general scope of interests specified in our charter."

Opener

THE Alumni Council held its 234th meeting, inaugurating this season's activity, at the University Club in Boston on the last Monday in October. Francis J. Chesterman, '05, President of the Alumni Association, presiding over the gathering of 74 members and guests, opened the meeting with greetings from new alumni term members of the Institute Corporation and introduced, as new members of the Alumni Council, Joseph W. Wattles, 3d, representing the Class of 1908; George A. Johnson, representative of the Class of 1923; and J. Merrill Hanley, '18, representative of the Technology Club of Rhode Island.

Highlighting the reports of officers and committees which constituted much of the business of the meeting was the report of Henry B. Kane, '24, Director of the Alumni Fund, which showed that at the end of the seventh month of its fourth year the Fund had received $91,984.94 from 7,590 Alumni. Both figures, Mr. Kane stated, represent advances over the record for last year at the same time. The total of contributions has increased 15 per cent; the number of contributors, 4 per cent; the average contribution, $1.15 over last year.

Resolutions in memory of Herbert T. Gerrish, '08, were presented by H. Leston Carter, '08, chairman of a committee including Franklin T. Towle, '08, and Henry K. Spencer, '09. They emphasized Mr. Gerrish's long service on the Council as class representative since 1910. A silent rising vote accepted the resolutions.

Alumni Day 1944 will be held on Saturday, February 26, not on March 4 as previously announced. Chairman of the event is Herbert R. Stewart, '24, elected at this session of the Council.

As speakers of the evening, the Council was fortunate in having both Dr. Compton and Vannevar Bush, '16. President Compton reviewed informally the widely varied work of the Institute during the year past, commenting upon the unusual demands it has imposed upon staff and facilities and evaluating it as a contribution to the war effort. He then introduced Dr. Bush, who discussed differences between this war and previous ones, explaining how the scientific organizations in Washington and elsewhere throughout the country are co-operating to further the military activities of the nation.

Conflict, Colleges, and Contracts

THE vast program of training for Army and Navy personnel which American colleges were asked to undertake this year brought many new and unsuspected problems involving not only changes in curricula and acceleration of class schedules but new and perplexing administrative procedures. Not the least of these problems was that of the contractual relationships between the government and the educational institutions. These contracts cover facilities and services that include the housing and feeding of thousands of students, the teaching of special courses based on the academic standards of the particular institution, and in many instances the provision of comprehensive physical training programs, all on a no-profit, no-loss plan.

To establish a plan for uniform procedure throughout the country, assuring fair terms and provisions in all contracts, the armed services joined in the creation of the Joint Army-Navy Board for Training Unit Contracts. In addition to two members each from the Army and Navy, the board includes four representatives from the nation's educational institutions. These college administrative officers were asked to serve on the board as consultants, and they were chosen for their broad knowledge of educational business methods and their reputations for achievement in this field.

It is not surprising, therefore, that one of the college representatives is Horace S. Ford, the Institute's very able Treasurer, or that Technology was one of the first institutions to negotiate a contract with the Army Air Forces, when it undertook the training of a large group of meteorological students last spring. Mr. Ford's associates in the college group are Rufus C. Harris, President of Tulane University; Robert G. Sproul, President of the University of California; and Robert B. Stewart, Controller of Purdue University, who serves as chairman of the board, representing both branches of the armed services. Representing the Navy are Captain Cortlandt C. Baughman and James A. Fowler, Jr., counsel, Bureau of Naval Personnel, while the Army members are Colonel William F. Volandt, assistant chief of the Air Staff, Training, and Lieutenant Colonel Blake R. Van Leer, chief of the facilities branch of the Army Specialized Training Division of the Army Service Forces.

The board has already accomplished much in anticipating problems that were certain to arise in negotiating contracts with a large number of institutions and has accelerated the publishing of Army and Navy manuals of procedure. It has approved uniform contract forms acceptable to both branches of the services and has developed standards to be applied in determining the rates for payment for college services and facilities. Above all, the board has made possible cordial and effective relations between the armed services and the country's educational institutions in a program of training that has required readjustments in space and time which colleges have never before been called upon to face.

Promoted

ROSS M. CUNNINGHAM, Assistant Professor in the Department of Business and Engineering Administration, has been promoted to the rank of associate professor of marketing. Professor Cunningham joined the staff of the Institute in 1937. He was graduated from Harvard College in 1928 and was awarded the degrees of master in business administration and doctor of commercial science in 1930 and 1934 by the Harvard Graduate School of Business Administration, where he served as a research assistant from 1930 to 1931 and as instructor in sales management from 1931 to 1934. He held the post of associate professor of marketing at the University of Tennessee from 1934 to 1937, serving at the same time as an associate in economic research on the Tennessee Valley Authority.

William A. Reed has been advanced from the staff position of assistant to that of instructor in the Department of Chemical Engineering. He was graduated from Harvard in 1942 with the degree of bachelor of science and has just completed the work for the degree of master of science at the Institute.

Visiting Committee Report

WORK of the Institute's Department of Biology and Biological Engineering is reviewed by the Corporation Visiting Committee for that Department in a report which The Review, in keeping with custom, summarizes below:

CONDITIONS resulting from the war made inadvisable a meeting of the Committee on the Department of Biology and Biological Engineering * during the past year. Several members of the Committee, however, discussed the problems of the Department with its Head, Professor Francis O. Schmitt.

The Department's subjects are essentially of professional grade, and, as in other similar Courses, the number of students has been reduced by the war to a small fraction of the normal figure. The demands on the staff in connection with research problems directly associated with the war have, on the other hand, greatly increased. Some members of the staff are on leave of absence to the govern-

* Members of the Committee for 1943–1944 are H. B. Richmond, '14, Chairman, Philip W. Moore, '01, William L. Campbell, '15, Duncan R. Linsley, '22, George B. Darling, '27, Detlev W. Bronk, and Thomas C. Parran.

ment. Much of the research work is being handled directly on contracts with government agencies. The Department, therefore, has had to operate on a day-to-day basis, and has not had the opportunity of initiating the changes it had hoped. Much thought is being given to the postwar period.

The public health option will be closed next June, in accordance with a previous recommendation of the Committee and by approval of the Corporation. The Course in Sanitary Engineering has already been combined with the Department of Civil and Sanitary Engineering.

For future solution is the determination of the best method of integrating the work in fundamental biology with the more obvious immediate applications in the field of biological engineering, which include the currently important subject of food technology. This must be done so that not only will work be carried on in current techniques but also fundamental research will be initiated and will lead ultimately to broader horizons. While the immediate administration of these activities does not present unusual problems, the long-range program presents many questions which must be considered by future Visiting Committees.

Fiscal 1943

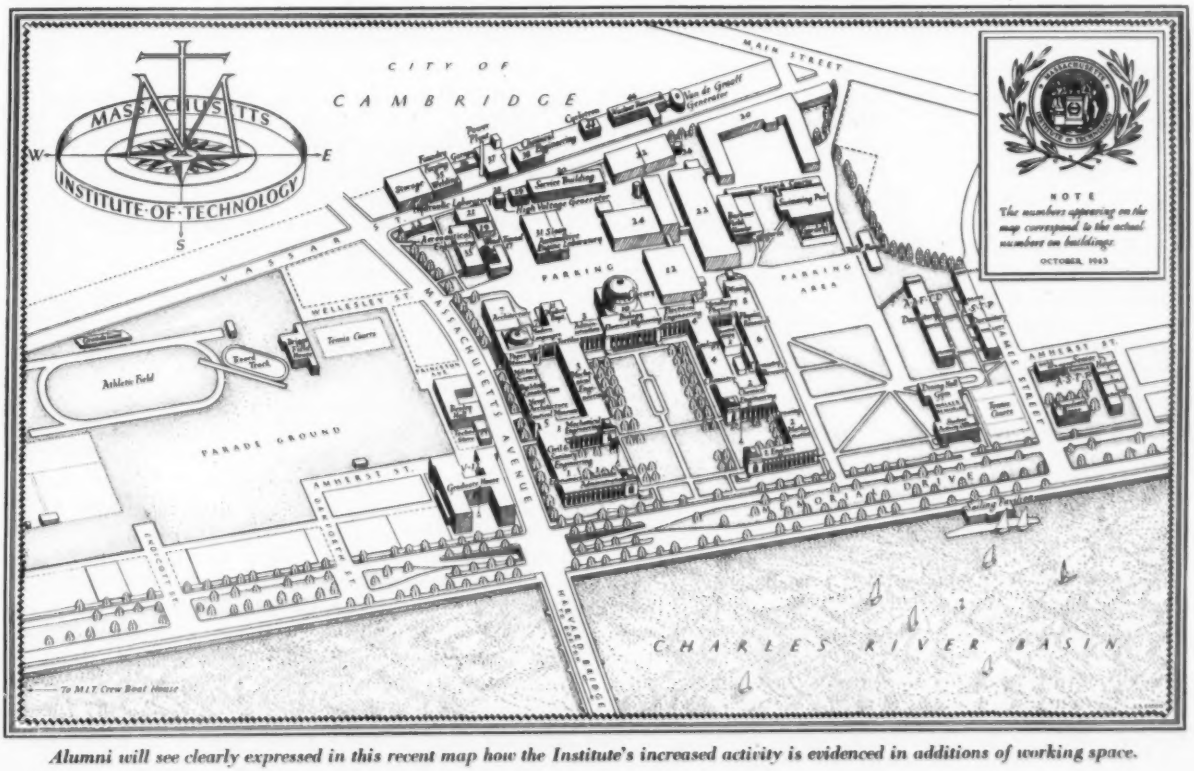
FROM the annual report of Horace S. Ford, Treasurer of the Institute, presented to the Corporation at its most recent meeting, an impressive picture is to be had of the way in which Technology's financial operations have been magnified by the special loads of wartime activity. Thus whereas in normal times the operation of the Institute occasions an annual turnover of $4,000,000 to $4,800,000, fiscal 1943's transactions amounted to some $23,700,000. Of this sum, $4,700,000 were involved in the performance of the Institute's normal teaching, research, and administrative functions. Nineteen million dollars were involved in transactions having to do with war research, war training, and current fund operations connected with these.

Of this total of $19,000,000, the sum of $15,800,000 was under the supervision of the Division of Industrial Cooperation. During the year, 162 contracts were handled, of which 120 are still in force. One effect of this work appears in the increase of floor space this fall by more than 200,000 square feet in addition to the half-million square feet added during the past fiscal year.

The book value of the Institute's investments increased $720,000 during the year, Treasurer Ford reported. Market value advanced nearly $6,000,000, the ratio of market to book value on June 30 reaching 106 per cent, as compared with the ratio of 91 per cent recorded for fiscal 1942. United States Government bonds composed 28 per cent of all investments at the close of the year — the largest holding the Institute has had. Stocks amounted to 46.3 per cent. Mortgage holdings and cash advances for war-research and war-training contracts made up the remaining 16.7 per cent. Investment income declined, the allocation of 3.6 per cent to the pooled funds being the lowest recorded.

Portrait

THE excellent portrait of George Eastman, painted several years ago by Seymour M. Stone of New York, has been presented to Technology by Mr. Stone. The portrait of the Institute's great benefactor had previously been loaned by the artist and has been on exhibition in the library of the Eastman Research Laboratories.



Alumni will see clearly expressed in this recent map how the Institute's increased activity is evidenced in additions of working space.

THE REVOLUTION AT KITTY HAWK

(*Concluded from page 84*)

kites.) Likewise, the Wrights' idea of using a chain drive was not new. The Wrights were, however, the first to know that a loss resulted from superposing and how much that loss was; and their crossing of the driving chain into a figure eight was a new idea. But the important Wright inventions did not have to do primarily with superposed surfaces or the chain drive.

The noteworthy fact is that no matter what the Wrights used in the way of devices or knowledge possessed by their predecessors, they could not have flown except for fundamental scientific discoveries of their own — not to mention all they discovered regarding the flying art *after* they had first flown.

Knowledge of how to build wings of a shape to support a man-carrying, powered plane in the air — knowledge which they got by wind-tunnel experiments — was probably the Wrights' greatest contribution. They might have flown without use of their plan of presenting the right and left wings at different angles to the wind; or, rather, they might thus have flown a short distance in calm air — enough to demonstrate that flight was possible. But, on the other hand, it was the Wrights' basic method of lateral control which makes the airplane practical today. And, as already mentioned, their discovery of the use of the rear rudder as a balancing device, rather than as a steering mechanism, was fundamental. Their front rudder, which prevented nose dives, though not in use today, was itself a discovery of prime importance in carrying the inventors through the experimental stages. No predecessor had touched on any of the basic principles that made the Wrights' achievement possible, even if we do not include their work on propellers, which gave them knowledge far beyond any previously available regarding propulsion; and even if we do not mention additional improvements and inventions they made *after* the Kitty Hawk flights of 1903.

A few students of aviation seem to have thought that gliding machines which had been built before the Wrights', and which were capable of short, steep glides, could have been made capable of powered flight by merely a few minor additional touches. One should remember that though the Wrights' 1902 glider was leagues ahead of any ever built before and could have been propelled by only about half the power needed for any earlier glider, their first powered machine was not simply the 1902 glider with power added. Aside from containing an engine and propellers, the 1903 machine was a great improvement, as to dynamic efficiency, over the 1902 glider.

Another fairly widespread notion seems to be that French experimenters were close upon the trail of the Wrights and would probably have flown before long, even if there had been no Wright brothers. Actually, the knowledge that led to the first successful French experiments came from the Wrights. When their friend Octave Chanute, in a lecture and in writing at Paris in the summer of 1903, revealed the facts about the Wrights' 1902 glider, he made possible the beginning of French aviation.

It was as true in the United States as in France that no one had been ahead of the Wrights in designing a machine that could fly. In the trial of the patent-infringement lawsuit brought by the Wrights against Glenn Curtiss in 1909, the defendant's attorneys sought to show that the Wright inventions had been anticipated by earlier experimenters. But the Wrights won their suit.

The aim of this brief survey of the record has been to make clear that the Wrights owed little to others for the physical components of their epochal invention. Their debt was rather for inspiration. Now, 40 years after the event, that debt has been discharged to a large degree by the usefulness of the inventors' achievement, by the air lines that encircle the world, and by the aerial fleets that carry war home to the aggressor. And now the debt that *we* owe to the Wrights may be greater than ever if, as is hoped, the airplane becomes an instrument to unite the world and insure peace.

SMOKE, BUT NO FIRE

(*Concluded from page 87*)

getting up steam. They are also used to fill in the gaps. As soon as an unbroken smoke blanket extends from the outermost line of generators to the vital point, the area of the blanket is enlarged by moving the generators farther out, so that finally some of the screen may be several miles from the target the enemy is seeking to destroy. It is important that the outermost rank of generators be located on a broken line so that the smoke blanket will not appear as artificial to an enemy bomber but will produce the illusion of a natural terrain feature. Around a harbor or where the vital area is near the water, the generators may be placed on barges designed by the Chemical Warfare Service for this purpose.

The chemical smoke-generator companies are able to get into operation quickly and effectively. Within a few minutes after a warning is given, clouds of smoke begin to billow over the point to be protected. Recently one of the companies stationed in North Africa was called upon to screen a newly captured port. Four minutes before the first wave of enemy bombers came over the port, the warning reached the company. Smokepots were lighted immediately on an inner line close to the target. Somewhat farther out, the M1 generators were put into operation. Hostile bombers came over in wave after wave in a raid that lasted nearly an hour. The target was so well covered that they did not score a single hit on the vital area, and no damage was caused. Operations of this sort successfully protected North African ports for weeks at a time, saving many hundreds of lives and untold property.

But the technical man was already working on an improved model before the reports came in from the field. The soldier is never completely satisfied and always demands still more mobility and portability. He is always seeking new uses for his tools of war. He found the mechanical cloud maker so effective for back areas that he tried it closer to the front. In the North African theater it was used to protect all sorts of military and naval installations. In that theater, however, the soldiers complained that this machine, made and intended for use around industrial centers and within the zone of the interior, wouldn't stand the gaff of active warfare. Then the complaint was that the machine was too big and cumbersome for protecting areas near the front. The result of the demand from the front is a new cloud maker, one-tenth the weight and size of the old one, and small enough to be carried on a jeep. This will make much more smoke, weight for weight, than even the M1.

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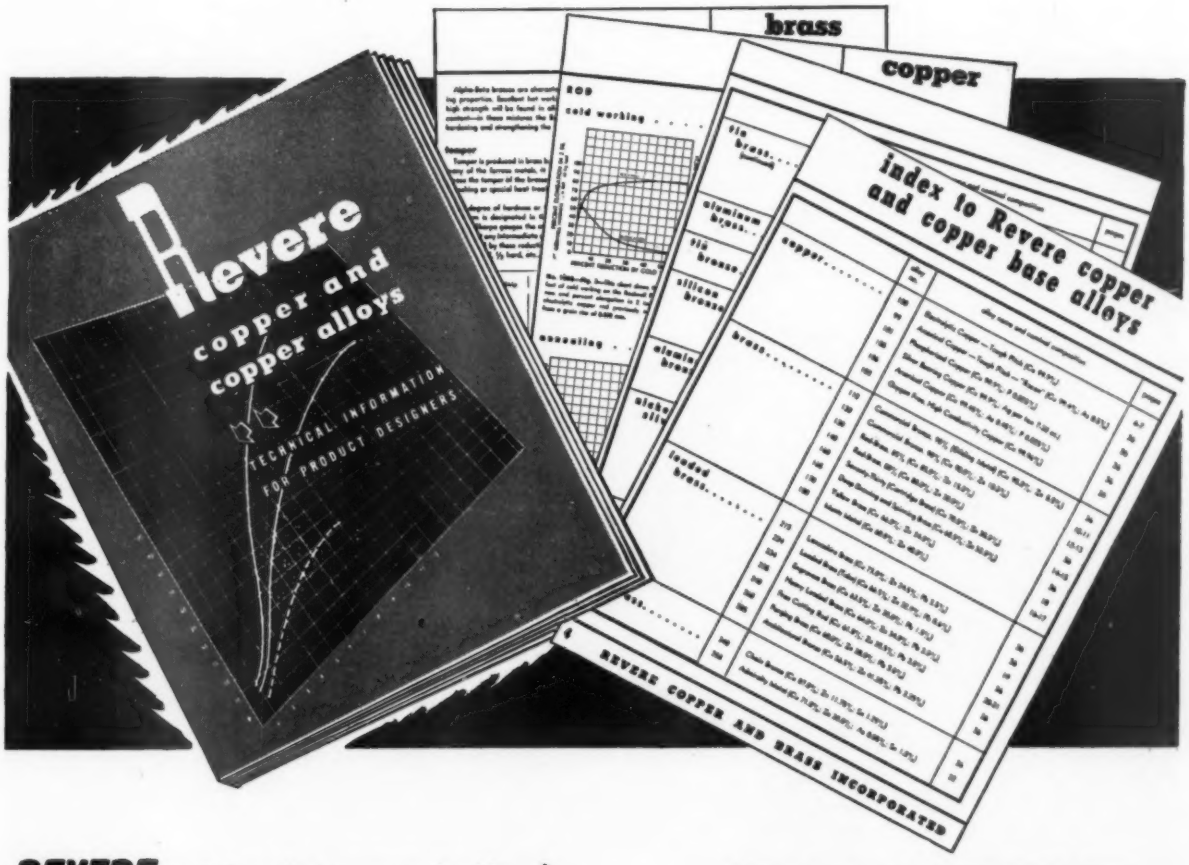

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TODAY'S AIRPLANES TOMORROW

(*Continued from page 89*)

can foresee the sort of world to come from the holocaust. A certain number of our surplus aircraft will have to be scrapped in any event. The close of war will find many of our air transports located at remote fields throughout the world. Overnight the standards by which aircraft are valued will undergo radical revision. No longer will many of these aircraft be in condition to meet the peacetime test of airworthiness. The cost of reconditioning and possible rebuilding plus the flight or shipment costs to a home base will have to be carefully measured against the plane's value there when the market has already become surfeited with similar equipment. No doubt a careful on-location survey of all war transport aircraft, in the light of various considerations of cost and value, should be undertaken as a first step, in order to determine what equipment is not worth reconditioning or salvaging.

Nevertheless, in addition to the equipment which is written off and destroyed and the equipment immediately needed to relieve the acute shortage of aircraft in commercial service and to expand commercial operations, there will undoubtedly exist a surplus sufficient to take care of military peacetime needs and replace manyfold the pre-war fleets of all of the world's air carriers.

There is no simple solution to the problems which will be presented by the government's possession of this huge balance of transport aircraft. The government might authorize the return of the surplus supply to the various manufacturing concerns in order to permit each factory to convert its own type of aircraft to commercial usage and resell them under appropriate regulations calculated to prevent evils not now foreseeable. Obviously, this would be a vast and complex undertaking, and the disadvantages that would surely follow could well be greater than the disadvantages it was designed to avoid.

Or the government could enter upon a policy of preserving the surplus aircraft in a separate pool for use in any future contingency. Although commercially — where economy of operation is a controlling consideration — it is important to have the most modern and efficient types of aircraft, this is not a controlling factor when a period of national emergency is involved and operating cost is relatively unimportant. The establishment of such a reservoir would involve, of course, the building and maintenance of large storage facilities.

Far more realistic to my mind than any of the possibilities which I have mentioned or than any of the many others which could be suggested today is the proposal that adequate machinery be set up now to handle the problem in whatever way may best accord with the national interest and national policies at the time these matters must be decided. We do not know today how long the war will last; how many surplus aircraft we shall have; what kinds they will be; how many might be efficiently used by our own air lines; how many should be made available to foreign air lines; what special rehabilitation, emergency, or relief measures will have to be undertaken by these transport aircraft; how soon manufacturers can produce new and more modern types; how much charter or contract service will be undertaken at the end of the

(*Continued on page 100*)

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TODAY'S AIRPLANES TOMORROW

(*Continued from page 98*)

war; what the international arrangements will be for controlling and regulating international air traffic; or what the volume of that traffic may be permitted to be. We do not know who will be in the aircraft manufacturing business or, for that matter, the answers to many other important questions which should be available in whole or in part when action is taken. Hence it would seem wise at the moment to devise such machinery as will permit all of these questions and their answers to be taken into consideration at the appropriate time so that wise national policies and conclusions can then be formulated and the appropriate action taken.

Bearing upon all these problems is the fact that unless considerable work is done toward the development of purely commercial aircraft prior to the close of hostilities, we can anticipate a period of from two to five years before new commercial types are available for the market. In the meantime, the needs of our civil air lines, of reconstruction and relief operations abroad, and of foreign countries will have to be met from war-produced aircraft even if they are not so efficient as the postwar aircraft industry will know how to build.

I may seem to have placed too little emphasis upon the construction of smaller types of aircraft and upon the problems which will confront the manufacturer of parts and accessories. The problems of these latter businesses are no less acute than are those of the transport-aircraft producer; but in a brief review it is necessary to concentrate on one branch. All branches of the flying-equipment industry should receive the same careful attention in the determination of national policy.

Exceedingly important is the question of how we can set up machinery which will place the government in a position to do what is necessary when the time comes. An aviation-conscious Congress, recognizing the problem, has before it House Bill 2959, which would provide such machinery. Introduced by Representative Clarence F. Lea of California, chairman of the House Interstate and Foreign Commerce Committee, this bill as presently constituted proposes to place in the Civil Aeronautics Board the responsibility for handling the surplus aircraft problem, and grants broad powers to the board in the disposition of surplus aircraft owned by the United States. In the process of disposing of all surplus equipment, the board will be required to weigh the effect of its policies on the economic soundness, efficiency, and safety of the existing domestic and international air transport system of the country. It is also charged with the burden of pursuing a course that will preserve the economic soundness of the aircraft-manufacturing industry.

Under the proposed measure, all Federal departments having ownership, possession, or control of surplus aircraft which were manufactured or in process of manufacture on or prior to the date one year following the cessation of hostilities are authorized to transfer such ownership, possession, or control to the board. From that point on, it becomes the board's responsibility to dispose of the surplus aircraft as it sees fit but in keeping with the policies set forth in the bill. The board is given wide latitude in the manner in which it chooses to dispose of

(*Continued on page 102*)

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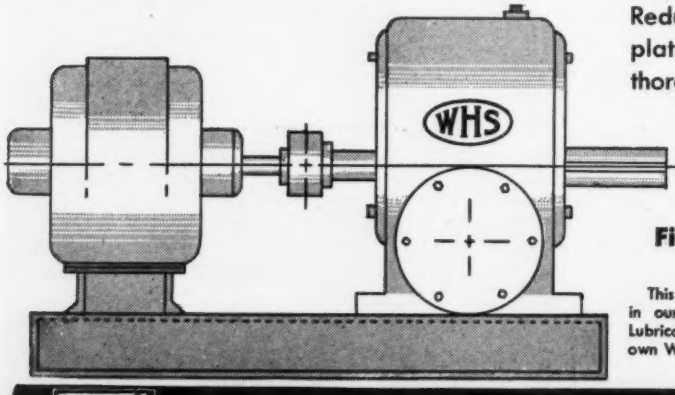

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TODAY'S AIRPLANES TOMORROW

(*Continued from page 100*)

all surplus aircraft. It can sell, lease, charter, exchange, or otherwise dispose of aircraft and parts owned by it, with or without advertising and under such terms as it may determine. Further, it is not limited in the financial arrangements it may desire to make in accepting payment.

Obviously, the proposed legislation contemplates the conduct of individual business transactions by the government. From the nature of things, this is an inescapable consequence of the government's ownership of surplus aircraft in such quantity and in such circumstances that the immediate disposal of them at the war's end is out of the question. One should keep in mind that we are here dealing with public assets costing, perhaps, several billions of dollars.

The objectives of the bill are worthy, and I believe that the Civil Aeronautics Board, charged already with the duty and responsibility of fostering the sound development of an air transportation system, should have a large part to play in the disposition of the surplus aircraft. It is believed, however, that other departments of the government have vital concern in this disposition, and I am authorized to say that it is the board's view that the instrument for carrying out the provisions and intent of this bill should be a corporation, the board of directors of which should include representatives of the War Department, the Department of the Navy, the Department of State, the Department of the Treasury, the Department of Commerce, and the Civil Aeronautics Board.

This, then, is the machinery through which I believe the most satisfactory solution can be attained. If I seem to have raised large problems and indicated vast and complicated vistas without recommending any concrete solution, I have done so because no solution is possible today. The only great step which can be taken now is the establishment of the machinery for handling the problems to which I have referred. To me the taking of that step promptly is of the greatest importance.

The magnitude and complexity of the problems with which any agency set up to administer the surplus aircraft will be confronted must be clearly recognized. Even with the broad powers and the wide latitude of action contemplated in this pending legislation, such an agency will on occasion be faced inevitably with the necessity of choosing among several possible courses, none of which is wholly satisfactory. Only wishful thinking could lead to a conclusion that a reserve of several thousands of transport aircraft could be so administered that in any and every conceivable circumstance nothing whatever would be subtracted from the potential markets of the manufacturers. The mere existence of these aircraft in any capacity offers a dangerous degree of competition.

As has been pointed out, the pending legislation contemplates that the surplus aircraft will be maintained, administered, and liquidated in a manner to preserve the economic soundness of the nation's air-transport and aircraft-manufacturing industries. But neither the intent of Congress nor of the government agency which will have responsibility for the reserve could completely remove the threat to air-transport markets so long as the

(*Concluded on page 104*)

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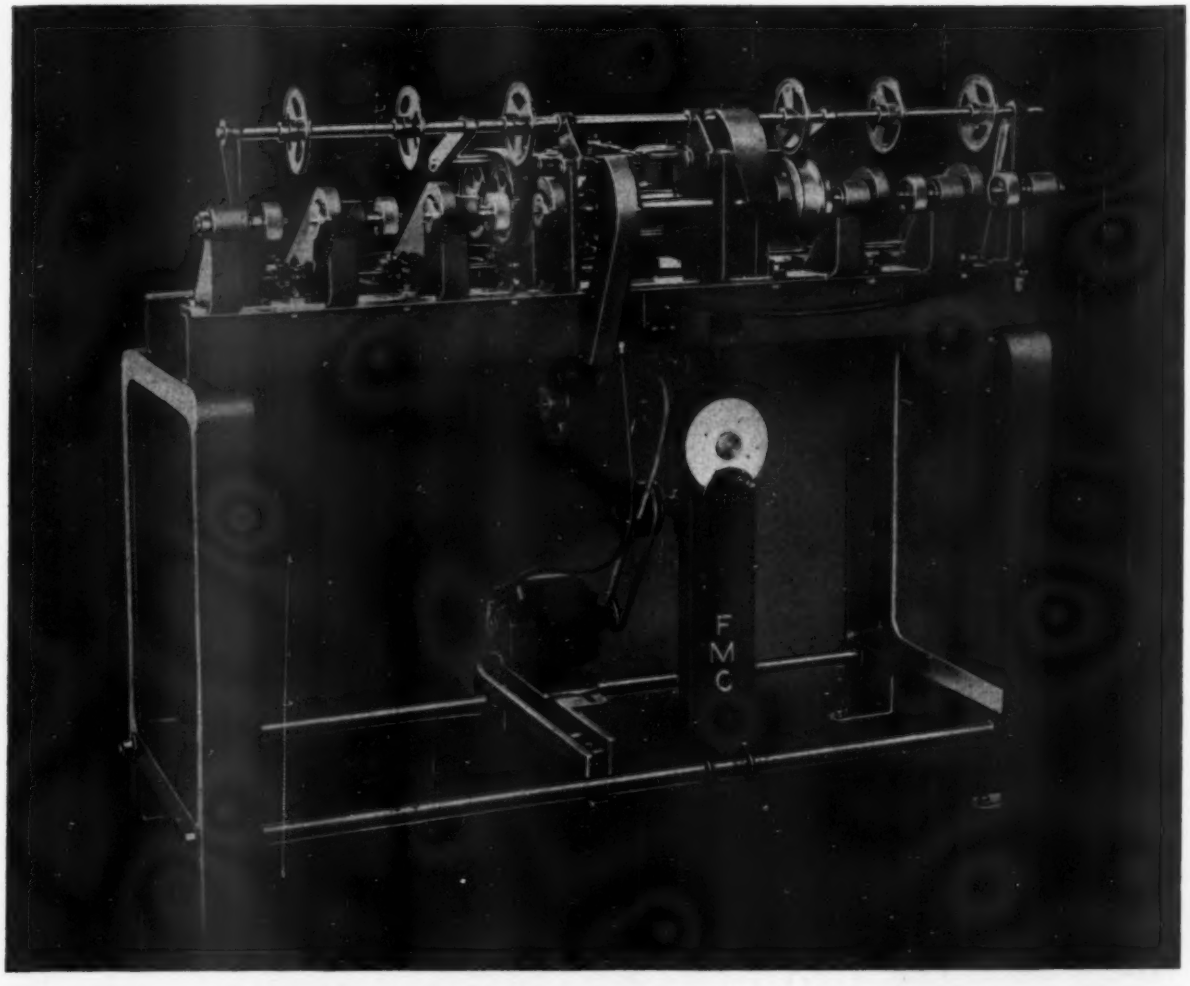

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TODAY'S AIRPLANES TOMORROW

(*Concluded from page 102*)

aircraft which compose that reserve are on an approximate par of efficiency with aircraft in production by the manufacturers. If the end of this war finds the aircraft manufacturers limited to the capacity to grind out exact replicas of those aircraft of which a large surplus is already on hand, and finds them unable to place upon the market, soon after the war, aircraft which are appreciably more efficient for commercial service than those already on hand, then as a nation we shall have missed a great opportunity. The war may, of course, force us to miss it; let us hope not. The term "postwar planning" has a pleasantly reassuring sound. It brings to mind a picture of broad-scale blueprints of the future and other comprehensive activities. But I venture to assert that any postwar planning which does not provide for aggressive, practical application in the factories of this country just as soon as the war program permits is a form of self-delusion.

To find time and a way to launch and develop those activities which at the war's end will place our factories in a degree of readiness to produce what they *should* then be capable of producing is a matter of distinct national concern. To find time to develop new and better models of transport aircraft, ranging from small but efficient types suitable for local services, to large transoceanic air liners, is the problem. I have faith that if this problem can be worked out in harmony with the requirements of war production, our American manufacturers and airline operators need have little concern for the competition from postwar surpluses of war transport aircraft.

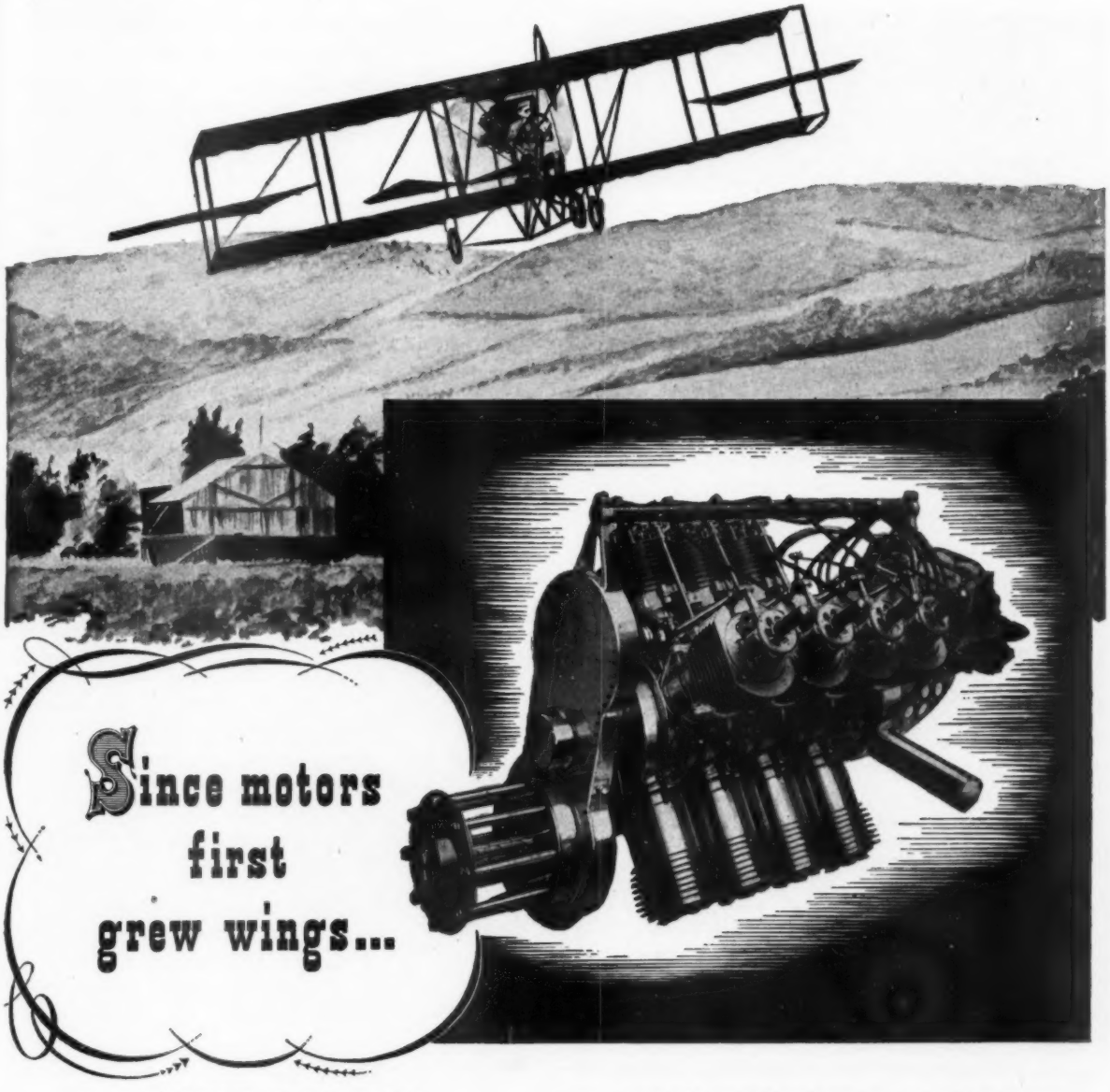
INDUSTRIAL BUILDING TRENDS

(*Continued from page 91*)

erection of factory buildings than to that of either apartments or offices. Lofts, offices, and apartments are all erected for tenant occupancy. The building cycles for these structures have many common features: Building costs assume a much larger role in stimulating or retarding construction of such new buildings than is true with ordinary factory buildings. Industrial plants are merely means to an end, as owners expect their profit not from ownership of buildings but from manufacturing operations carried on within the buildings. Owners of lofts, offices, and apartments, however, seek their return from the net income derived from buildings; they have nothing to do with activities of tenants. The cost of such a building, together with the cost of land, constitutes practically the whole capital investment from which future income is to be derived. Abnormally high construction costs and high interest rates jeopardize the financial success of a tenanted building. The tendency is for these buildings to be erected, therefore, not only when both building costs and interest rates are low but when the vacancy rate is so low as to assure a sufficient rental to make construction profitable.

In contradistinction, the erection of new factory buildings is influenced by the earnings of an organization in its currently occupied plant, rather than by interest rates or speculative considerations. They are seldom erected for rental purposes, nor are they often built for

(*Continued on page 106*)



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INDUSTRIAL BUILDING TRENDS

(*Continued from page 104*)

purposes of resale. Most plants are constructed for owner occupancy as a fixed investment. Unlike office, hotel, and apartment-house construction, where each building project is in most instances a new unit, a considerable volume of industrial building is in the nature of enlargement to existing plants. The erection of factory buildings, therefore, follows rather than precedes industrial earnings.

New plants are timed very largely with reference to the need for new productive capacity. Desire to reduce high unit costs also is a powerful factor in stimulating new construction. Pressure for new and larger buildings becomes particularly strong with the introduction of new technologies, whether they involve new processes, new materials, new products, new mechanical equipment, or new sequences in the scheduling of manufacture and assembly of merchandise through the plant. Since old concerns, in order to maintain a competitive position, must equip themselves with each new technological improvement as it is introduced, the construction of new industrial plants may at times be practically unrelated to the current level of profits. New construction may occur despite an excess of vacant factory space, if such space because of size, shape, location, or manner of construction is unadapted to the most efficient methods of manufacture.

Industrial organizations, then, build new or larger plants not when costs are low but when new or larger

(*Continued on page 108*)

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INDUSTRIAL BUILDING TRENDS

(*Continued from page 106*)

quarters are needed. Factory buildings, though built as well as or better than residential buildings, are more vitally affected by technological changes, and, as a result, they are often withdrawn from use long before their full structural depreciation. The necessity for new factory buildings is often occasioned more by the changing technique in manufacture than by the pressure of increased demand for additional space.

Industries are of two types: (1) "basic," or primary, industries, which are devoted to manufacture of goods or rendering of services in interregional trade; and (2) secondary industries, which are engaged in production of goods or services for the community itself. Growth of secondary industries tends to follow population, and where these have reached a point of meeting current requirements of the community, future growth must be slow. These limitations do not apply, however, to basic industries, whose ability to expand is determined not by size of population but by the marginal competitive advantages possessed by local as against outside manufacturers in common regional markets.

The view so prevalent a few years ago that multistory buildings are more economical than single-story buildings is no longer held by industrial engineers. First of all, multistory buildings are usually built upon more expensive land. Then, too, a multistory structure has considerable waste space, which would be economized for use in the single-story structure. Thus to serve the upper floors, a multistory building must have elevators, which necessitate shafts and walls to enclose them, not to mention the expense of operating the elevators. The upper floors must also have stairways and fire escapes. Higher walls involve either thicker walls or larger columns. Floors in single-story buildings, resting directly upon the ground, can as a rule carry any live-load weight, whereas in multistory buildings increased live-load requirements are reflected immediately in higher construction costs. The old idea that the smaller roof area in a multistory building effected such an economy in construction as to make the multiple-story building cheaper than the one-story structure has been shown to be erroneous, because the combined cost of the roof and of the floor resting upon the earth in the single-story building is less than the cost of the structural floor serving as floor and ceiling in the multistory building. The net result of these various economies is to make the cost per square foot of usable floor area approximately 25 per cent less than that of a five- or six-story building having the same gross floor area. In some lines of industry, whether land costs $5,000 or $50,000 an acre makes no difference — the one-story factory building is still the more economical.

When the price of land exceeds $50,000 an acre — that is, about $1.25 a square foot — the carrying charges become, because of increased investment, so heavy as to make one-story factory buildings uneconomic. This condition tends not so much to prompt the erection of multistory industrial buildings upon high-priced land in the central portions of cities as to encourage the migration of downtown plants to suburbs where they may obtain land at a sufficiently low price to permit erection of one-story buildings.

(*Continued on page 110*)

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INDUSTRIAL BUILDING TRENDS

(*Continued from page 108*)

Other things being equal, industrial buildings situated on low-priced land are the more attractive investment. High land values add to interest, amortization, and taxes, thus increasing the cost of manufacture. They also constitute, in proportion to their amount, an increased threat to the stability of the real-estate investment of an organization. In times of depression, land values fall more rapidly than building values. A plant located on high-priced land in the heart of a city is, therefore, more vulnerable to a severe depreciation in land values than one located on low-priced land in the suburbs. In boom times, moreover, a plant located in the center of a city is more likely to experience an increase in the value of its land than is one located in the suburbs — a doubtful advantage since the increase is usually accompanied by higher taxation and cannot be realized, short of a sale and removal from the premises. Such conditions have, during the past few years, served to accelerate the industrial development of low-priced land in suburban communities.

Recognizing the fact that it is the part of wisdom to take the profits due to appreciation in land values, many organizations with plants on high-priced land have in an increasing degree disposed of downtown plants and, with the proceeds, erected plants on less expensive land in the suburbs or beyond the city. As a result, a valuable but nonproductive asset in high-value land may sometimes be converted into a more productive manufacturing plant possessing both lower unit costs and larger capacity. In other words, the organization sells an asset which, as a result of inflated land values, not only contributes nothing constructive to its purposes but saddles it with increased costs. With the funds realized from the sale, it is able to re-establish the business more firmly in a new locality. Under these conditions one need hardly be surprised that the central portions of cities are rapidly losing such industries as are not dependent upon the local market for the sale and distribution of products.

After studying building and equipment problems in order to try to increase flexibility of layout and operation so that proper balance will be maintained between departments, and to gear operations so that each will synchronize and mesh with the one preceding and succeeding it, some companies have found a smaller one-story building, incorporating modern conveniences, better suited to their requirements than a multistory building with from two to three times the same floor area.

By affording better control of each element entering into production, new buildings designed to meet requirements are effecting not only a substantial reduction in plant investment but an appreciable decrease in production costs. Hand in hand with these economies goes an improved quality of product, with less breakage, fewer rejects, and less waste. The profits to be derived from new buildings frequently enable an organization to write off the entire plant investment in from three to five years.

The modern industrial building is primarily a machine for the production of commodities. The column arrangement must fit the lines of machines, the receptacles for merchandise, and the handling of goods for packing and shipping. If bays are too big, excessive costs will be incurred in large columns and heavy steel framing. Then,

(*Concluded on page 112*)

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INDUSTRIAL BUILDING TRENDS

(*Concluded from page 110*)

too, care must be taken not to diminish normal ceiling heights through the use of inordinately deep girders. At the same time, vibration under stress of heavy machines must be avoided through the provision of adequate load capacities and proper reinforcement.

The daylighting of one-story industrial buildings differs from that of the multistory lofts in that illumination of the central part of the building may be supplied through the roof by monitors, saw-tooth windows, or skylights, and the room area may be indefinitely extended in width as well as length and yet every part of the room will be supplied with adequate daylight. As a result of the high sill level of saw-tooths, monitors, and skylights, nearly all daylight reaching the working plane is from the higher angles of the sky. The illumination from such windows is, therefore, less subject to obstruction and shadows than that from ordinary vertical windows which receive a considerable proportion of their skylight from nearer the horizon. Concentration of a considerable area of glass in a given cross section permits a high intensity of illumination to be obtained throughout all interior portions of the building.

The stability of employment and pay rolls in a community depends upon the extent to which its investments in industrial plants and equipment are in low-cost capacity. Only localities possessing plants with the lowest unit costs can reasonably expect minimum irregularity in employment and pay rolls. It is here that the defense program, in providing a minimum of 500,000,000 square feet of competitive floor space in new industrial plants, constitutes a real challenge to cities in nondefense areas, particularly to cities with a considerable volume of space in obsolete structures. Presumably this new space will be thrown upon the market for manufacturing and storage purposes after the war. It will prove especially available to plants producing goods for either a regional or a national market. How will the absorption of this space affect the industrial position of the many cities, particularly in New England and the North Atlantic States, having an undue proportion, if not nearly all, of their manufacturing space in 40-, 50-, and even 60-year-old plants?

This situation will present a problem to hundreds of communities. The advancement and even the maintenance of living standards rest upon the institution of all possible economy in the production and distribution of goods. These communities must, therefore, find some way early in the postwar period to equip local industries with as modern and efficient plants as are to be found in the defense areas. Otherwise they may face a major liquidation of factory employment and pay rolls.

The changes now occurring in the construction and location of manufacturing plants promise not only revolutionary changes in the industrial structure of each community but basic readjustments in the city plan. Indeed it may be a question whether, over the longer term, the consequences of new types of factory building may not be as important in the effect they will wield upon the physical organization and plan of communities as upon industry itself. So that the original efficiency of these new plants shall not be impaired, no less than that their relocation shall not prejudice the highest development of communities, their sites must be planned in the strictest harmony with the urban areas of which they are such an intimate part. In other words, the permanent usefulness of these new industrial plants calls for a more intelligent, effective, and broader regional control over the use of land than has heretofore characterized our planning policy.

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THE TREND OF AFFAIRS

(*Concluded from page 82*)

It commenced the undertaking on the afternoon of February 20, when an Indian farmer working in his cornfield near the town of Parícutin, about 330 miles from Mexico City, felt the ground begin to shake, heard deep subterranean rumblings. Smoke began to rise from a small depression in the field. Dirt and rocks were spewed forth from beneath the smoke. The farmer left for town. Today, his field is occupied by an active, growing volcano some 1,000 feet high and about 3,000 feet through at the base. Two near-by towns have been rendered virtually uninhabitable by its ministrations, which have covered the ground for miles around with a layer of ash and cinders. Five miles away, the layer is still about a foot thick. Dust from the volcano has been collected in Mexico City.

Called Parícutin, this energetic infant is not only, like all new volcanoes, a geological rarity but is also one of the very few which have been continuously observed from the start by informed personnel. As Mexican volcanoes go, it is comparatively accessible, being situated near one of the principal highways of the region so that, in the early stages, spectators could drive their cars almost to the foot of the cone. Although it has not attracted so much attention from scientists or laymen as would be expected in normal times, the volcano early became somewhat of a tourist item. Nothing startling to geologists has been observed, however. Parícutin displays the usual spectacular symptoms, but is disappointingly conventional in its characteristics. The great masses of dust and gas released, the rapid growth of the cone (starting from a flat field, it reached a height of 180 feet in its first four days), the steepness of its sides, the lightning playing in the black column of smoke above the crater — all are typical volcanic phenomena.

Formed by the falling back of rocks and cinders thrown up from the vent, volcanic cones tend to be symmetrical. The slope of the cone depending on the angle of repose of the dry material or on the angle of flow of viscous lava, the sides are apt to be steep, as is true of the Mexican newcomer. When the lava is exceptionally fluid, however, volcanoes can have very flat and massive profiles. Mauna Loa, one of the five giant volcanic mountains which compose the island of Hawaii, is over 13,000 feet high and from 50 to 75 miles broad at its base.

Michoacán, the state in which the farmer's cornfield bore this unusual crop, is dotted with scores of similar cones, many of very recent origin, geologically speaking: One of them appeared not long after the Spaniards had entered this region.

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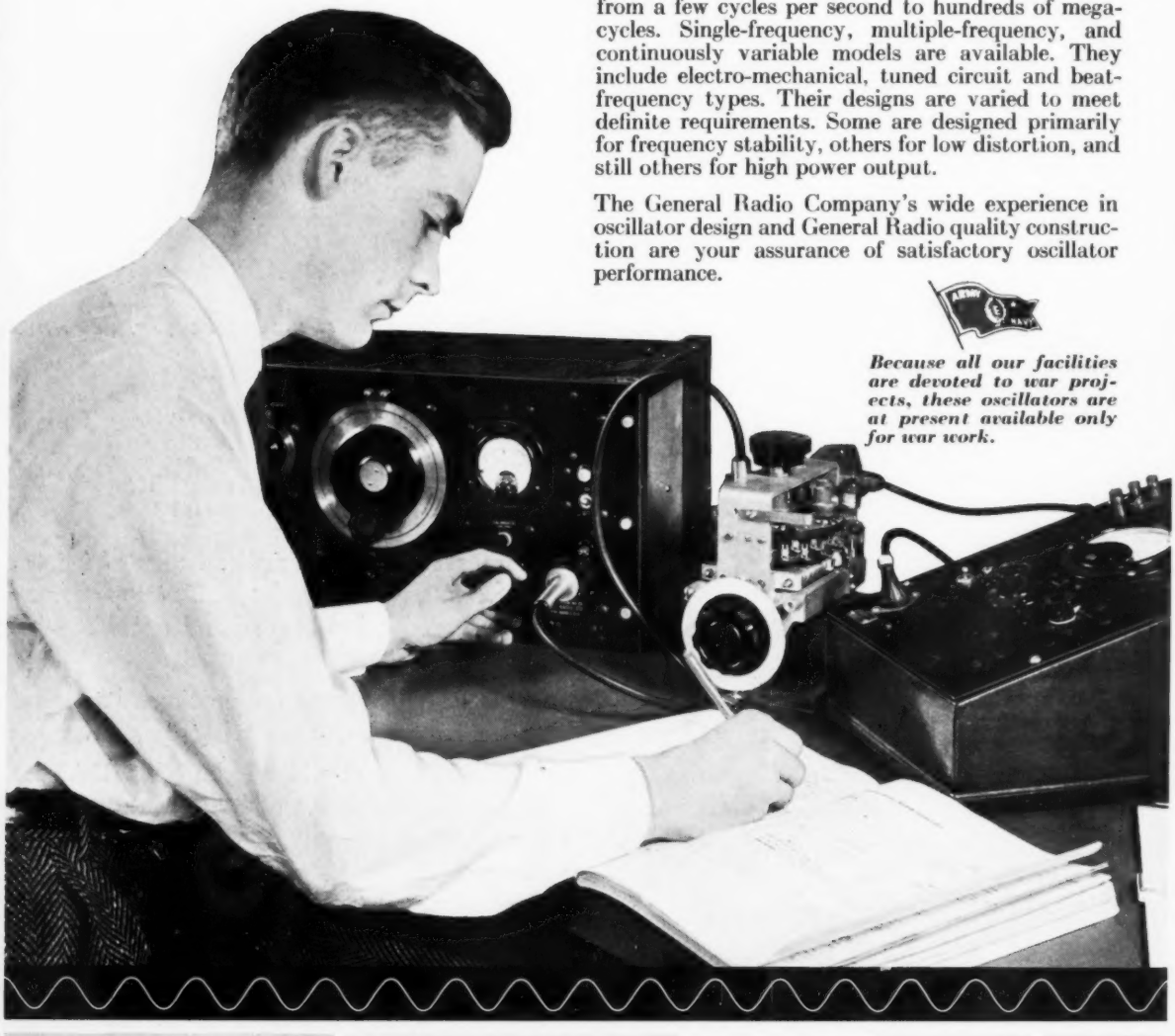

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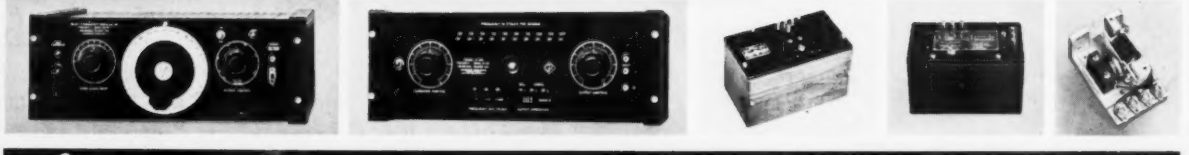

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